Kent

UNITED

DC-8 NOISE ABATEMENT ENGINEERING COORDINATION MEMO

PAGE 1 of 171

RELEASE DATE 4/4/75

REVISED

TO: Kent Bourquin * BY:

FROM: Rik Anderson BY:

SUBJECT: Phase II Engineering Flight and Guest Pilot Evaluation Report

REFERENCE:

COMMENTS: The subject report is attached. Since the appendices are somewhat lengthy, only the addressees noted with an asterisk (*) have received copies of them. Additional copies are available upon request.

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EXOFT - Larry Berryhill
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RESULTS:

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UNITED AIRLINES

PHASE II

ENGINEERING FLIGHT AND GUEST PILOT EVALUATION REPORT

November 15, 1974

PREPARED UNDER CONTRACT NO. NAS2-7475

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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FOREWORD

Paragraph 2. VII. g of the Statement of Work, National Aeronautics and Space Administration Contract NAS2-7475 as modified by Amendment 4, requires submittal by United Airlines of a report presenting the data and conclusions of the engineering and guest pilot evaluations. This report is submitted in fulfillment of that requirement.

INTRODUCTION

The Engineering Flight and Guest Pilot Evaluations were the second and third parts of the evaluation of noise abatement approaches in a DC-8-61 airplane. They were conducted in accordance with the Engineering Flight Evaluation Test Plan dated October 5, 1973.

Prior to the flight evaluation, the two-segment profile capabilities of the DC-8-61 were evaluated and flight procedures were developed in a flight simulator at the UA Flight Training Center in Denver, Colorado. The flight evaluation reported herein was conducted to determine the validity of the simulation results, further develop the procedures and use of the area navigation system in the terminal area, certify the system for line operation, and obtain evaluations of the system and procedures by a number of pilots from the industry.

Due to software delivery delays by the equipment contractor, the Engineering Flight Evaluation was conducted in two phases. In Phase I the Collins Mark II ANS-70A hardware was installed and the basic system-aircraft interface was tested and verified. Then, utilizing the RNAV computer as a general purpose computer, it was programmed to provide a variable two-segment profile to permit verification (or modification) of the profile geometry and flight procedures developed for the DC-8-61 in the Simulation Evaluation.

It was determined in Phase I that the DC-8-61 is adaptable to an upper segment flight path angle of 5 1/2°, and that the aircraft can be stabilized on the ILS glideslope at 500 feet above field level (AFL) when the 5 1/2° upper segment intersects the glideslope at 575 feet AFL.

In the Phase II evaluation the full area navigation capabilities of the special equipment installed were developed to provide terminal area guidance for two-segment approaches. The objectives of this evaluation were as follows:

(1) Perform an Engineering Flight Evaluation sufficient to certify the two-segment system for the six-month In-Service Evaluation.

(2) Evaluate the suitability of a modified RNAV system for flying two-segment approaches.

(3) Provide evaluation of the two-segment approach by Management and Line Pilots.

SUMMARY

Verification of the full-capability RNAV/Two-segment system proved to be complex and time consuming. Troubleshooting the two-segment system functional and performance problems was compounded by persistant problems associated with the basic RNAV hardware and software. Attempts to utilize the system's normal functions often revealed basic software or hardware problems which had to be corrected before further evaluation of system performance and accuracy could proceed. As a result of these problems, the testing of the system's lateral and vertical guidance capabilities was significantly more complicated than it should have been.

The Phase II Evaluation consisted of 210:31 flight hours during which 677 two-segment approaches were attempted. At the conclusion of the evaluation, based on three demonstration flights and the pre-service approach checks, the FAA Western Region issued a Supplemental Type Certificate (STC SA2865WE dated June 7, 1974) permitting in-service use of the ANS-70A area navigation system to fly two-segment approaches.

A Guest Pilot Evaluation was conducted in which 180 approaches were flown by 31 pilots. Pilots representing airline management , the Air Line Pilots Association, aircraft manufacturers, and the FAA participated. While some of the pilots who participated expressed reservations about the procedure under certain adverse environmental conditions, and a few expressed reservations about potential industry-wide implementation, none indicated that it was unsafe or imprudent to proceed with the In-Service Evaluation.

The conclusions of the Phase I and II Engineering Flight and Guest Pilot Evaluations are as follows:

- The two-segment approach profile appropriate for the DC-8-61 is a 5.5° Upper Segment which intersects the ILS glideslope or the computer generated 3° Lower Segment at 575' above touchdown.

- The RNAV two-segment approach commences at a precisely defined waypoint nominally 6-7 miles from touchdown and 3000-4000' above touchdown. Some undesirable flight characteristics may occur if the same waypoint used to define the initiation of the two-segment profile is also used to define the lateral intercept of the final approach course.

- Airspeed and configuration are critical in the DC-8-61 for commencing descent on the Upper Segment. The profile is well-guided and is easy to fly if the proper conditions are set at the entry to the approach.

- Approach progress annunciations and warnings of unreliable guidance are satisfactory. Protection from failure to capture the ILS glideslope is safe and adequate.

- The pilot's operational flexibility is limited with the RNAV system because he must select the entire approach profile, including runway, type of approach, and initial altitude well before reaching the airport. Any last minute change to the planned approach imposes an operational hardship because of the complexity of altering the flight plan. Such changes invite the possibility of a missed approach due to the time required to enter them in the RNAV system and for the system to assimilate them. However, the addition of an approach guidance capability to the basic system does not add unacceptably to the workload if the pilot is familiar with the basic system management, and results are good when the programmed lateral and vertical path can be followed to and through the approach.

- The equipment and procedures are safe and acceptable for in-service evaluation provided:

  (a) The pilots are adequately familiarized in basic system management and in the two-segment procedures, and a technician is aboard to assist the Captain with the evaluation.

  (b) Appropriately conservative weather minimums are set for the evaluation. UA has established 500 feet ceiling and 1 mile visability (500-1) for RNAV/ILS and 800-2 for RNAV/RNAV.

  (c) The approach is limited to 15 knots or less of tailwind on the upper segment, and is not used in icing conditions.

  (d) Efforts continue throughout the evaluation to improve equipment reliability and approach repeatability.

TEST DESCRIPTION

Aircraft and Equipment

The aircraft used for the Engineering Flight Evaluation was United Airlines DC-8-61 N8099U. This aircraft was used for both Phase I and Phase II of the Engineering Flight Evaluation, and is presently being used in the In-Service Evaluation.

A Collins ANS-70A Area Navigation System was installed in the aircraft. This system is a Mark II type area navigation system which had been originally designed without consideration of its potential to provide two-segment approach guidance, or any other approach guidance interfacing with the existing Instrument Landing System (ILS).

The software used in Phase II and subsequent flying enables full use of three dimensional RNAV system, including both enroute and terminal area navigation guidance. This evaluation is limited to the terminal area noise abatement approach capabilities of the system.

The RNAV system provides guidance on a waypoint-to-waypoint basis. Waypoints are defined within the system in terms of latitude, longitude, and altitude. Aircraft present position is determined using available radio and air data information, and the RNAV system provides the guidance necessary to follow the desired RNAV waypoint-to-waypoint path.

The two-segment profile used throughout the Phase II Engineering Evaluation consisted of a 5 1/2° upper segment which intersected the glideslope or lower segment at 575 feet. This was the optimized profile developed in the Simulation and Phase I Evaluations. The upper segment is defined by two waypoints, "Upper" and "Lower". The lower segment is defined by the ILS glideslope for RNAV/ILS approaches. For RNAV/RNAV approaches the lower segment is a 3° path defined by two waypoints, "Lower" and "Touchdown." (Figure 1)

The RNAV system consists of a digital computer (the Navigation Computer Unit-NCU), a Flight Data Storage Unit (FDSU) for program and navigation data storage and retrieval, a switching unit which provides the interface between the RNAV system and existing aircraft systems and which provides reversionary (non-RNAV) system operation, a tuning line adapter unit to allow manual or RNAV-auto tuning of radios, and a Control Display Unit (CDU). The CDU provides the flight crew/system interface, allowing input of flight plan information and display of the stored and computed data in the RNAV computer.

To permit full utilization of the RNAV system and to provide all required display functions, certain modifications and additions to the standard aircraft equipment complement were necessary. Figure 2 is a simplified system interface diagram. The Captain's VOR receiver was modified to provide sine and cosine station bearing outputs for use by the RNAV computer. The Captain's existing ARINC 521 DME interrogator was replaced with an ARINC 568 DME to permit the RNAV computer to tune it with ARINC 2X5 control lines, and to provide a distance readout compatible with the RNAV computer input. An additional DME interrogator was added to enable the RNAV system to obtain DME-DME position fixes. The Horizontal Situation Indicator (HSI) was replaced with a new unit with two distance displays (one for RNAV computed distance to waypoint). The course knob on this special unit served as the master RNAV engage switch. The Attitude Director

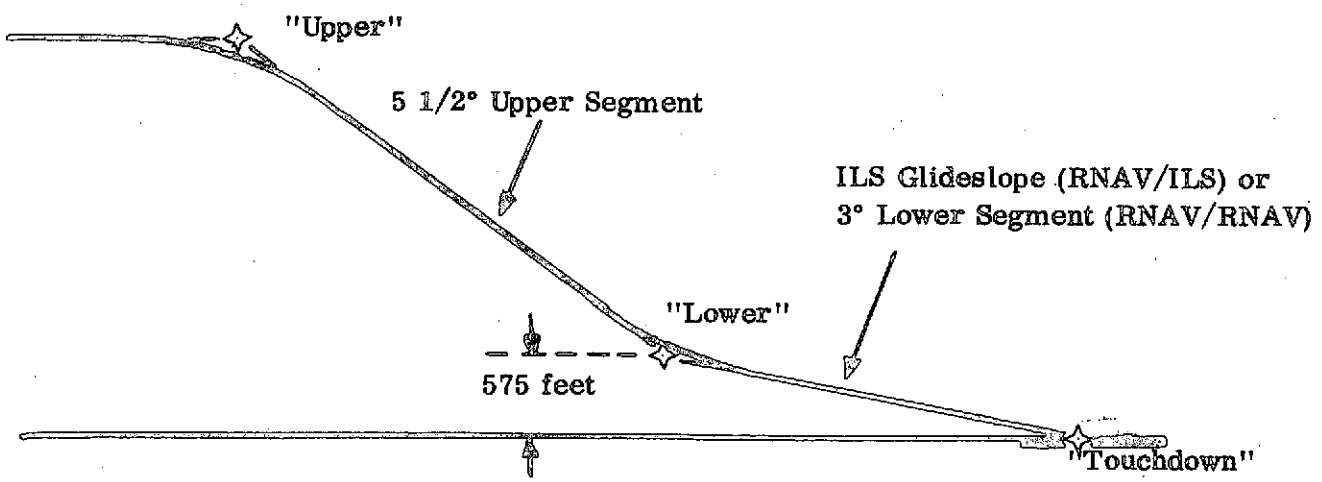

Figure 1
RNAV/Two-Segment Approach Profile for
DC-8-61 aircraft

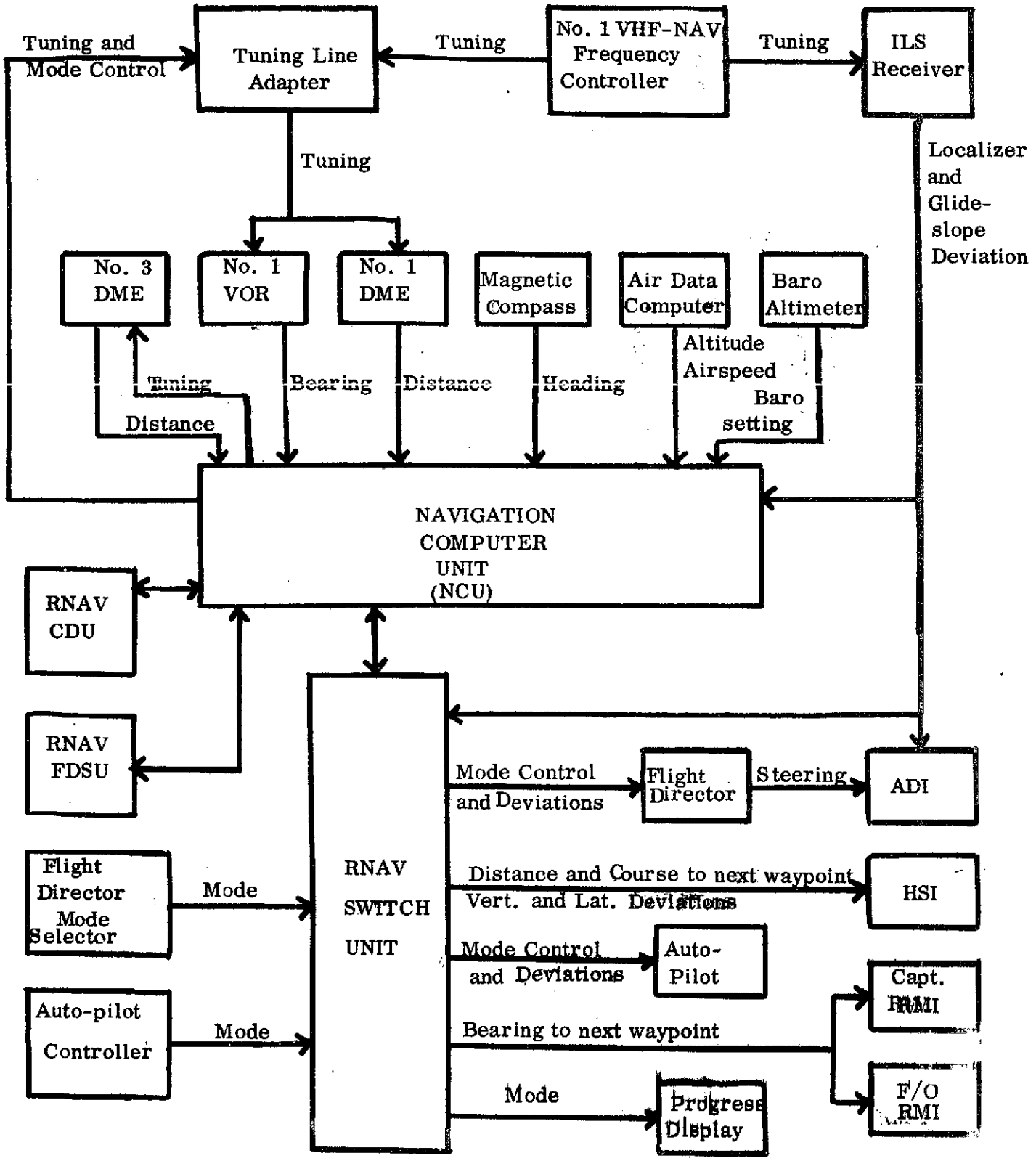

Figure 2
RNAV/Two-Segment Approach System
Interface Diagram

Indicator (ADI) was replaced with a unit which included glideslope and expanded localizer deviation displays. The air data system was modified to provide the RNAV computer with true airspeed, indicated airspeed, and barometric altitude referenced to 29.92 in. of Hg. The Captain's altimeter was replaced with one which had a potentiometer pick-off to provide the barometric correction setting to the RNAV computer. Since the existing navigation receiver had to operate in the VOR mode during an RNAV approach, an independent ILS receiver was added to provide the localizer and glideslope signals. This unit also operated as the ILS receiver in the non-RNAV mode. An RNAV mode position was added to the Captain's flight director mode selector, and the existing AUX NAV position on the autopilot controller was activated for selection of the RNAV mode on the autopilot. An approach progress display (Figure 3) was added to provide visual indication of proper flight director and autopilot mode selection and of the flight progress during two-segment approach operations.

The RNAV system interfaces only with the Captain's sensors and displays, (Fig. 4). All normal aircraft system functions are available when the RNAV system is not in use. When the RNAV system is engaged, by pushing in the course knob on the Captain's HSI following actions occur.

(1) The deviation displays on the HSI indicate vertical and lateral deviation from the RNAV flight plan entered on the CDU. This is annunciated by the mode indicator on the HSI which changes from RAD (radio) to RNV (area navigation).

(2) The Captain's DME display on the HSI is blanked out and the Distance to Waypoint display is activated.

(3) The course arrow is driven by the RNAV system to indicate the course to the next waypoint.

(4) The frequency control of the Captain's VOR and DME radios is transferred from the manual frequency selector to the RNAV system. This is annunciated by the illumination of the "VOR #1 AUTO-TUNED" light on the frequency selector. This light was added near the end of the Evaluation at the request of the FAA. The Captain's ILS receiver continues to be manually tuned with this frequency controller.

(5) The #1 needles on the Captain's and First Officer's Radio Magnetic Indicators (RMI) display bearing to the next RNAV waypoint. This is the only change to the First Officer's instrumentation as a result of the RNAV installation.

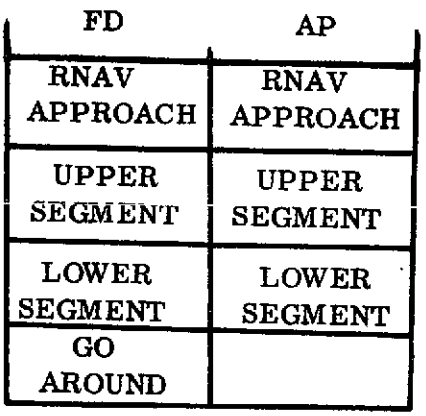

Figure 3. RNAV APPROACH PROGRESS DISPLAY
Lights illuminate amber (arm) and green (capture) to indicate status of approach. "Go Around" annunciator illuminates green only.

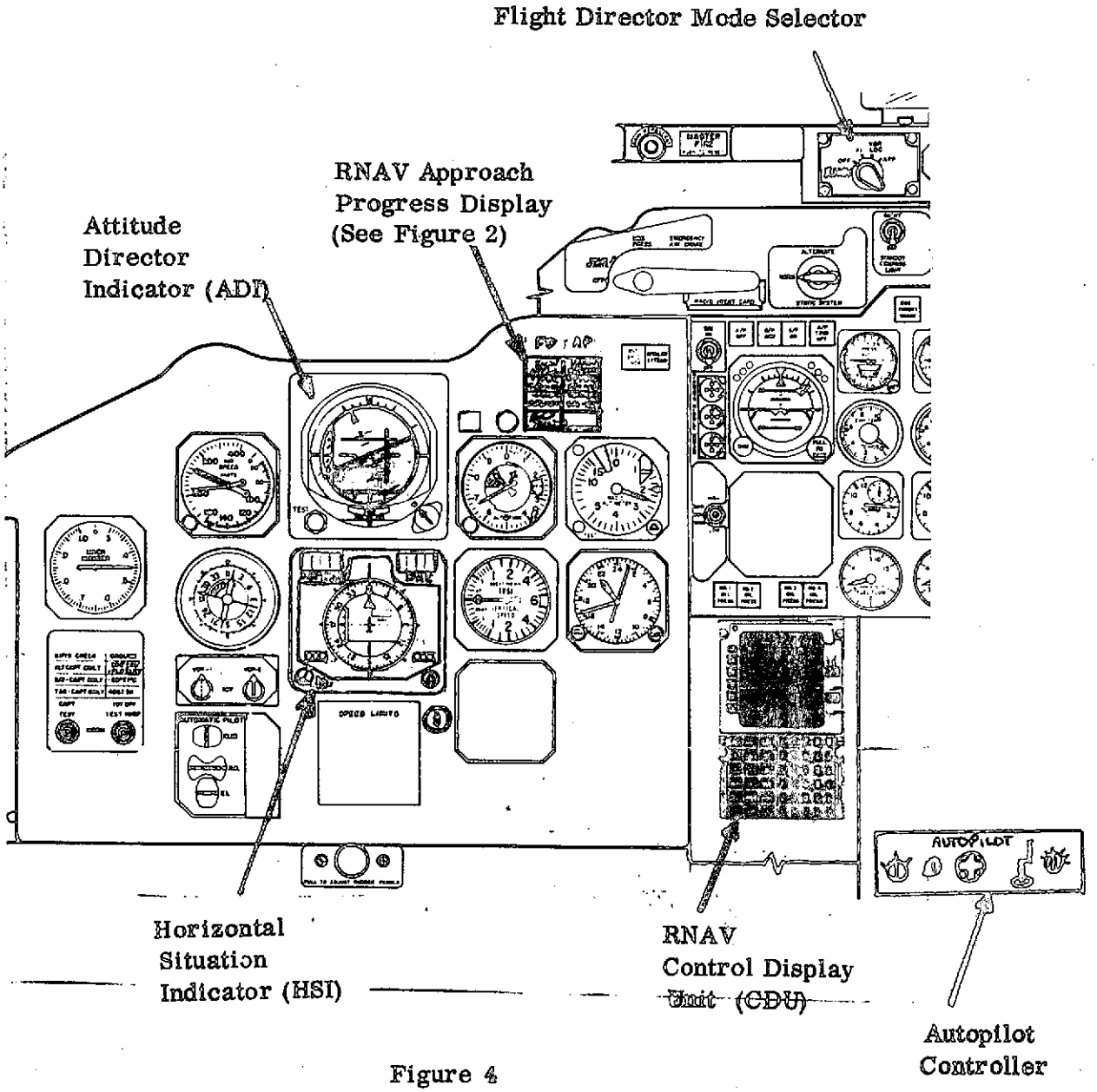

Figure 4
CAPTAIN'S INSTRUMENT PANEL

Test Procedure and Organization

The flight test team consisted of the Lead Project Pilot, four Project Pilots and three Flight Engineers, Flight Test Engineers, Program Director and NASA and Collins Observers:

Lead Project Pilot	-	John A. Morrison, UA
Project Pilots	-	Bill Brown, UA Fred Drinkwater, NASA "Monty" Monteith, UA Hal Snyder, UA
Project Flight Engineers	-	Art Causer K. O. Daudermann Jim Harrison
Flight Test Engineers	-	Tom Hammond Dick Nichols
Program Director	-	George K. Schwind
NASA Observers	-	Kent Bourquin Dallas Denery Fred Shigemoto Bill Wehrend
Collins Observers	-	Lee Belden Steve Nossaman Dick Rowland

Captain Gordon Brown (DC-8) and Captain Bob Stimely (727), UA Managers of Flight Operations Development participated throughout the evaluation.

The Project Pilot responsible for a particular flight occupied the Captain's position and flew the airplane and one of the other Project Pilots occupied the First Officer's position. A test observer recorded data and occupied the First Observer seat. The Second Observer seat was occupied by the data recorder operator.

All participants of each test flight attended a detailed briefing prior to takeoff. The briefing covered the objectives of that particular flight, the status of the two-segment system hardware and software, the data systems to be used on that flight and the duties of each person on board the airplane. Data cards were prepared for each approach prior to the flight. These cards were used by the First Observer to record pertinent data. Flights typically departed San Francisco for Stockton Airport using the standard navigation system. When out of the San Francisco area the RNAV system was turned on and flown to Stockton. The Pilot would fly the approaches at Stockton making comments for the video tape recorder

and for the hand-written record kept by the First Observer. The project pilot in the First Officer's seat handled the standard operating procedures (SOP's), monitored flight progress visually, and maintained radio communications as appropriate. The Project Flight Engineer assisted in SOP's and as visual monitor. Prior to commencing the approach the appropriate data was entered in the data recording systems. Following the approach the airplane was flown by the Project Pilot in the First Officer's position to a holding pattern or a downwind leg to set up for the next approach while the previous approach was reviewed and the next approach was discussed.

Phase II consisted of four types of flights: Avionics Verification, STC, Guest Pilot Evaluation, and Pre-Service checks.

Avionics Verification Flights

Because problems with the area navigation system continued throughout the evaluation, and experience with the system resulted in development of changes to the functional design of the system, much of the flight evaluation time was spent in avionics development and verification. Actual engineering evaluation as described in the test plan had to be fit into these flights where possible. The primary objectives of these flights were to test modifications to the system found necessary by previous flights or collect information to determine what modifications were necessary. Appendix A contains brief notes from the approaches made for avionics verification and/or engineering evaluation during the period February 2, 1974 through March 29, 1974.

STC Flights

Three flights were conducted at Denver and Pueblo on March 26 and 27, 1974 to demonstrate system operation to the FAA in order to obtain a Supplemental Type Certificate (STC) authorizing evaluation of the system in normal airline service. The STC flights were conducted in accordance with Type Inspection Authorization (TIA) No. T5315WE-DS (Appendix B). The FAA agreed to a full demonstration of the system as it existed at the time although previous evaluation had revealed the need for several changes or refinements to the system. These changes were demonstrated to the FAA during the Pre-Service Flight Checks in order to fully qualify it for certification. Based on these demonstrations the FAA Western Region issued Supplemental Type Certificate SA2865WE to United Airlines on June 7, 1974.

FAA participants in the certification flights were pilots Jim Bugbee and "Judge" Reynolds, flight test engineer Frank Hoerman, and engineer Dick Thompson. Nearly 8 hours of flight time was utilized, during which 30 approaches were made. Appendix C is a narrative of the certification flights, which were a comprehensive demonstration of the normal system operation and operation under conditions of system failures or mismanagement.

Guest Pilot Evaluation Flights

After a procedure had been developed which resulted in acceptable performance of the area navigation system in the terminal area and consistent two-segment approach performance, the Guest Pilot Evaluation commenced. During the period March 26 through April 6, 1974, thirty-one pilots representing aircraft manufacturers, airline management, the Air Line Pilots Association and the FAA evaluated the system.

Each guest participated in a two-day program. During the first day the pilot was given a detailed briefing and a simulator session. On the second day he flew six two-segment approaches at Pueblo. Due to the complexity of operating the RNAV system, particularly in the artificial situation of repeated approaches, project team members of the crew did the majority of the system set-up. Guest pilots were asked to focus their attention on the profile, procedures, and displays rather than the operation of the RNAV equipment.

Pre Service Approach Check Flights

The final out-of-service flights were conducted April 24 through 27 at the airports expected to be used for the in-service evaluation: Vancouver, Seattle, Chicago and Newark. These flights were made to check the navigation data base at these locations, confirm the acceptability of operational procedures developed to initiate the approaches, and demonstrate changes to the system to FAA personnel for certification.

The 54 approaches attempted are summarized in Appendix D.

During the approaches to Seattle runway 16, an RNAV procedure was used which closely followed the existing "Visual Bay Approach" presently used in visual conditions to provide noise abatement to the city of Seattle. These approaches demonstrated the applicability of RNAV systems to provide lateral approach path guidance for noise abatement. Details are provided in Appendix D.

Data Systems

Three primary on-board data systems were used during the Phase II Engineering Flight Evaluation. A digital flight data system recorded various aircraft and equipment parameters. A video tape system was used to record cockpit instrument performance during the approaches, as well as provide a cockpit audio recording. Approach data cards provided a means for the Project Pilots to organize the objectives of each flight, approach by approach, and to record the salient results of each approach for quick reference.

Digital Flight Data System

The digital flight data recording system is the data system which is also being used during the In-Service Evaluation. The recorder automatically runs whenever an RNAV approach is being flown.

The recordings were processed on a flight-by-flight basis and the data was printed in three formats. These separate printouts were produced to provide the information needed by the various data users. The Operational Evaluation Printout contained parameters selected and used primarily by the UA Project Pilot Team. The Concept Evaluation Printout included parameters selected primarily for technical evaluation of the two-segment approach concept. Parameters selected and used primarily by Collins Radio Company for evaluation of their Two-Segment Approach System design were provided in the Equipment Evaluation printout.

Video Tape Recorder

A portable video tape recorder was used to record the Captain's instrument panel during most approaches, except in the Guest Pilot Evaluation.

The video tape recorder provided an excellent means of verifying system performance and observer comments, and for detailed analysis of failures and abnormal operations to assist in system troubleshooting during avionics verification. In addition, the sound track provided a record of real time flight crew observations of the system's performance.

Approach Data Cards

The approach data cards were used by the Project Pilots to describe the objectives of each approach during flight testing. Each card described one approach in terms of profile geometry, flight parameters and test objectives and provided space for recording specific data and comments regarding the approach.

The cards provided an effective means by which the pilots could plan the evaluation flights. They were also a good index of the approaches which could be used to expedite search through the other media for specific approach data.

Procedures

Initiating an Approach

If an RNAV flight plan is followed into the Upper waypoint, the two-segment approach performance is good, however, one of the primary difficulties encountered with the RNAV system was getting it set up to make a two-segment approach if the aircraft deviated from the programmed flight plan. In such a case the RNAV system logic for returning the aircraft to the flight plan can cause certain two-segment approach logic functions to occur prematurely and make it necessary to abandon the approach. Some logic changes were made during the evaluation to minimize these problems, but it is still necessary to have a full understanding of the system operation to avoid an operationally induced abort.

One way to avoid these problems is to update the flight plan in such a way that it reflects the flight path which will be followed into the approach. There are two difficulties with this solution. First, under the present airspace structure, the air traffic controllers use radar vectors to position aircraft for approaches. These radar vectors cannot be readily predicted, particularly in heavy air traffic situations. Second, the RNAV system is very complicated to operate, and requires an in-depth understanding and good keyboard proficiency in order to update the flight plan while airborne in the busy terminal area. Even after the Project Pilots had attained good familiarity with the system, ATC terminal area entry procedures such as vectors for aircraft spacing or last minute runway changes often imposed an excessive workload on the crew which often led to cancelling the two-segment approach.

The method of coping with radar vectors on the ANS-70A is to use the heading command mode. However, the use of this mode was modified for use in the In-Service Evaluation to act as an "RNAV standby"mode. Two options were available to get out of the heading command mode: use the "heading armed" mode to arm the system to capture the inbound course or use the "direct to. . . . ."function.

The "heading armed" procedure consisted of (1) placing the system in the heading command mode, (2) zeroing the vertical speed command which is automatically inserted upon selection of the heading mode, (3) deleting any waypoints between the present position and the last waypoint prior to "Upper", (4) changing the course into that waypoint to the runway centerline course, (5) pressing the heading command button again to arm the system to capture the inbound course. Several problems with this procedure were encountered during the preservice approach checks. These problems could only be solved by operational limitations which were more restrictive than those associated with the "direct to . . ." procedure.

The "direct to. . . ." procedure consisted of (1) placing the system in the heading command mode (2) selecting "direct to . . . " either "Upper" or the waypoint preceeding "Upper" when the aircraft was vectored to the final intercept heading. This is the procedure which was finally selected for use in the In-Service Evaluation, due to the significantly reduced workload. One disadvantage of the "direct to. . ." procedure is that the aircraft is guided direct to the selected waypoint, and therefore may not necessarily align on the final approach

course. Also, the latitude-longitude turning point created could cause the aircraft to overshoot the final course, or it could be placed beyond the selected waypoint. (Software changes eliminated the latter problem prior to the In-Service Evaluation.)

The initial approach altitude (altitude of "Upper" waypoint) is fixed for each approach. It cannot be varied due to the way in which the two-segment approach capability was implemented in the ANS-70A. The system allows for flight plan programmed rates of ascent or descent into "Upper", but unsatisfactory upper transitions result if the aircraft is above the programmed altitude at upper capture. In such situations there is usually some overshoot of the upper segment, and the convergence back to the 5.5° path results in the aircraft following a slightly steeper path with an increase in the rate of descent.

Lead-in waypoints (those prior to "Upper") which are too close to "Upper" could cause difficulties in initiating an approach. It may eventually be advantageous to limit, by software, the configuration of waypoints leading into a two-segment approach (or any other approach). Suggested limitations based on the experience of this evaluation are (1) no waypoints closer than 1 1/2 miles to "Upper" and (2) lead-in waypoints should allow lateral and vertical stabilization on the inbound course prior to "Upper".

The FAA/Industry RNAV Task Force model for the terminal area RNAV waypoint configuration developed prior to consideration of RNAV/Two-segment approaches included an "8-mile" waypoint on each extended runway centerline 8 miles from touchdown, and two "5-mile offset" waypoints perpendicular to the inbound course at each "8-mile" waypoint, (eg. 8-mile waypoint" Union" and offset waypoints "Vault" and "Passe" on Stockton runway 29R approach - Figure 5). However, if the initial approach altitude is more than 3300 feet above touchdown, the distance from "Upper" to "Touchdown" is more than 6 1/2 miles; use of the "8-mile" waypoint as the final approach course intercept in such cases may result in unsatisfactory or uncomfortable upper captures due to not being established on the approach course prior to capturing the upper segment. If the 8-mile 5-mile waypoint configuration is to be maintained and be useful for two-segment approaches, initial approach altitudes will have to be limited to about 3300 feet above touchdown. If the 8-mile waypoint concept is not to be maintained, the potentially costly effects of extended downwind legs in order to make two-segment approaches from higher initial altitudes must be evaluated.

The procedures recommended for use during the In-Service Evaluation are provided in the Pilot's Operating Guide, a copy of which is provided as Appendix E.

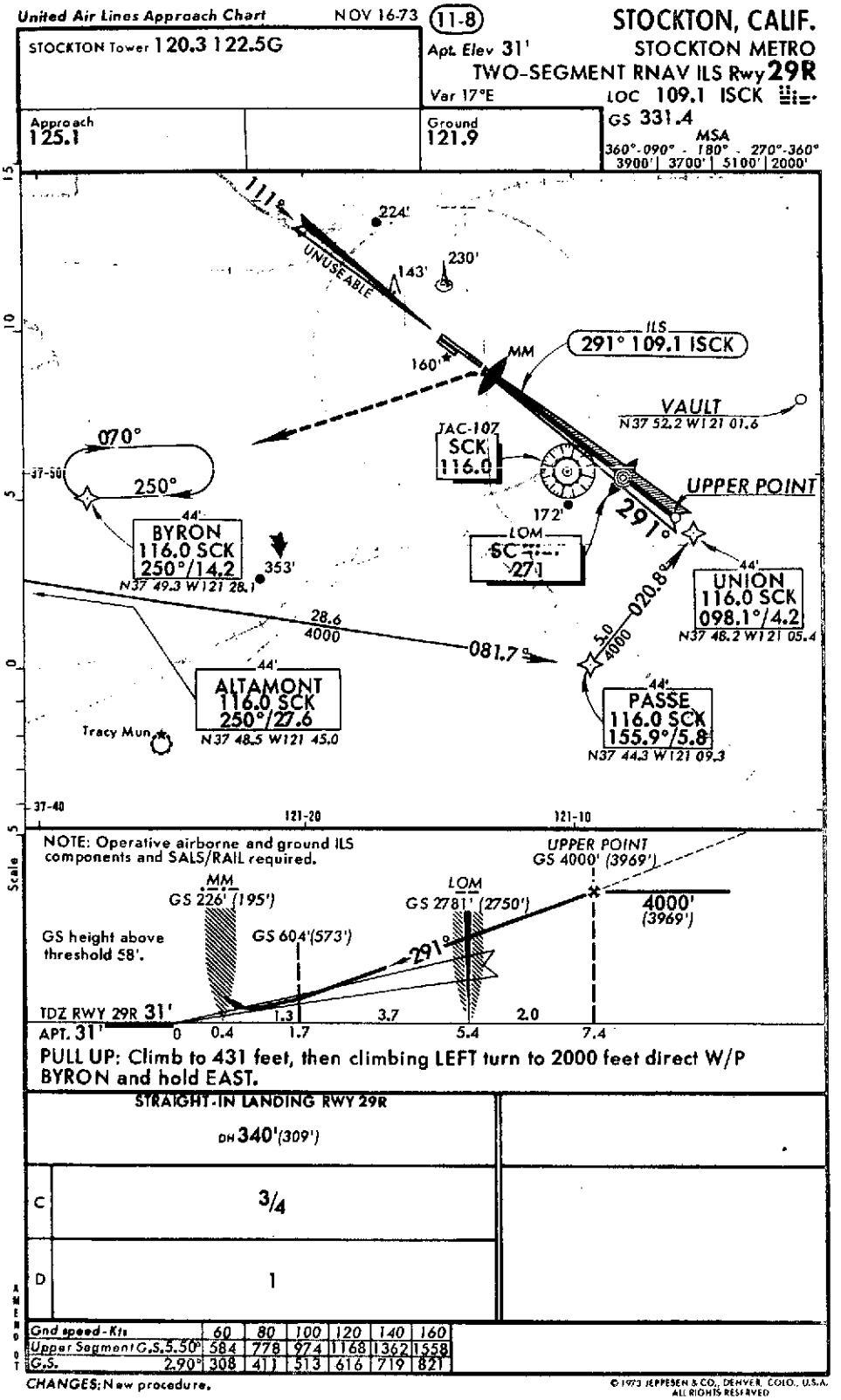

Figure 5
Typical RNAV/Two-Segment Approach Reference Chart
(For Illustration Only - Not to be used for Navigation Purposes)
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Two-Segment Approach Procedure

The RNAV system is programmed for the two-segment approach when a series of approach waypoints ("STAR" - sic) for the approach runway is loaded into the RNAV flight plan.

A noise abatement "STAR" consists of a set of four waypoints with pre-programmed, non-editable altitudes and courses: "Upper", "Lower", 'Touchdown", and "Runway End". Early in the evaluation a "Missed Approach Point" located at the runway threshold was used in lieu of "Touchdown" waypoint. However, the exact placement of "Missed Approach Point" varied from day-to-day due to radio aids variations. It had been determined that the system should disengage the autopilot and bias the flight director vertical steering bar out-of-view at "Missed Approach Point" rather than provide an automatic go-around capability. However, due to the variations experienced in the placement of 'Missed Approach Point", it was decided to move the point to the touchdown point (intersection of the glideslope or lower segment with the runway) to reduce the exposure to premature disengagements at low altitudes due to RNAV inaccuracies.

When the distance to "Touchdown" along the RNAV flight path is less than 30 nautical miles, the RNAV APPROACH annunciators (figure 3) are illuminated amber if the RNAV system is engaged (course selector on the HSI pushed in), and RNAV is selected on the flight director mode selector or AUX NAV is selected on the autopilot controller. When the distance to "Upper" is less than 15 nautical miles, the RNAV APPROACH annunciator illuminates green.

Eight miles from "Upper", the UPPER SEGMENT annunciator is illuminated amber and the HSIvertical deviation is switched to reference the extended upper segment. From this point until "Touchdown" is passed, the lateral and vertical path deviations are displayed for both RNAV/RNAV and RNAV/ILS approaches with sensitivities corresponding to those of nominal ILS facilities. If, at any time during the terminal entry operations, ATC requests the RNAV aircraft to deviate from its flight plan, the system must be placed in heading command mode until cleared for the approach. When cleared for the approach, the RNAV system is re-engaged as described in the 'Initiating an Approach" section above. The use of the heading command mode as designed, i.e. to cope with ATC vectors, was found to be unsatisfactory for several reasons. First, the workload involved in keeping the RNAV system up to date with vector commands is considerable since each new vector must be typed on the CDU and inserted. One possible solution to this problem is to connect the heading bug on the HSI to the RNAV system so that when the RNAV is in the heading command mode, setting the bug as is done in the non-RNAV situation inputs the new vector into the RNAV system. Second, the RNAV system commands a vertical speed equal to the vertical speed existing at the time when the heading command is selected. Even if the pilot enters a zero vertical speed through the keyboard, the guidance may cause a deviation from assigned altitude since zero vertical speed is not altitude hold. If, for example, altitude is lost or gained during maneuvering or because of flap extension, the desired altitude will not be re-attained while in a zero vertical speed mode. Another problem is that mode annunciation is poor. The only indication that the RNAV system is following a heading rather than the flight plan is on the progress page of the CDU.

The airplane flies towards the "Upper" waypoint in the approach configuration, with flaps usually at 15°. When the HSI vertical deviation bar moves into view, indicating that the aircraft is approaching the upper segment, the landing gear is extended. The configuration change cue provided by the upper segment deviation bar is similar to the cue provided by glideslope deviation on a standard ILS approach. When the upper segment capture point is reached, the UPPER SEGMENT annunciator is illuminated green and guidance is provided to transition to the upper segment. The transition is smooth, and is aided by the natural pitch down of the aircraft when the throttles are retarded. When "Upper" is passed, the distance to waypoint indication on the HSI provides distance to "Touchdown", even though the guidance is being provided to "Touchdown", since this is the distance of interest to the crew during the approach, even though the guidance is being provided to "Lower".

The LOWER SEGMENT annunciator illuminates amber when the distance to touchdown is five nautical miles. At the lower capture point the LOWER SEGMENT annunciator is illuminated green and guidance is provided to transition to the lower segment, or glideslope on RNAV/ILS approaches. The transition is again aided by the natural pitch up as thrust is added to maintain airspeed on the shallower lower segment.

The go-around mode is armed between the lower capture point and "Touchdown" waypoint. If the go-around switch is pressed, or upon passage of "Lower" waypoint on RNAV/RNAV approaches, or passage of "Touchdown" waypoint on RNAV/ILS approaches, the autopilot disengages, the flight director vertical steering bar is biased out of view, and the GO AROUND annunciator is illuminated and all other approach annunciators are extinguished. The flight director lateral steering bar continues to provide guidance to "Runway End" waypoint at the far end of the runway.

The guidance is removed at "Lower" on RNAV/RNAV approaches after the lower transition has been initiated as an indication to the crew that they should have visual contact with the runway. This is required because the RNAV/RNAV approach may lack the precision necessary to provide accurate guidance below 500 feet above touchdown.

Emergencies and Irregularities

Failures of the RNAV system, or those systems providing vital inputs to the RNAV system, result in the system aborting the approach. Further details of these types of failures are provided in the Safety Protection and Component Failures sections below.

Two irregularities which were specifically tested during the STC flights for their effect on two-segment approaches were engine failure and autopilot hardover failures. An engine was pulled back to idle while established on the upper segment of an RNAV/ILS autopilot approach. The other engines were advanced to compensate for the lost power and no rudder trim was required. The approach was continued on autopilot to 200 feet

above touchdown. On another approach an autopilot nose-down hardover was simulated at the lower capture point. The autopilot was disengaged six seconds after the failure and the maximum descent below glideslope was 1/8 dot.

The DC-8 two-segment approach was designed for use with full (50°) flaps on the upper segment. Accordingly, two-segment approaches should not be made when an emergency or irregularity requires that an approach be made with less than full flaps.

Weather Effects

Since the approach profile remained unchanged from the Phase I evaluation, no specific re-evaluation of the weather effects determined during Phase I was planned. However, conditions were encountered to verify the previously reported conclusion that the DC-8-61 can fly the 5.5° upper segment with up to 15 knots tailwind while maintaining a power setting on the engines which assures adequate thrust response. Severe wind shears were encountered during flying at Pueblo which revealed a shortcoming in the RNAV software: the wind estimate update cycle time was found to be too long for approach operations under conditions of wind shear. A change in the software was made to reduce the update cycle time, and satisfactory performance was demonstrated with a 30 knot shear from initial approach altitude to touchdown. Cross winds do not appear to affect the approach differently from standard approaches.

The DC-8 can make a two-segment approach during icing conditions with no adverse affects. The engine and airfoil anti-icing systems require sufficient bleed air that the throttles are advanced ahead enough to keep the manifold temperature high. Actual icing conditions were encountered at Pueblo during which this capability was demonstrated. (Ref 3/23/74 flights, Appendix A) However, this capability was not demonstrated during the STC flights and accordingly the system was not certified for use in icing conditions.

Avionics Flight Evaluation

RNAV System

The RNAV system installed for this evaluation is not simple to operate, and the use of the system in the terminal area with present ATC procedures is, in fact, difficult. The complexity of the system and the recurrent hardware problems resulted in a prolonged avionics verification period and a general lack of confidence in the system.

The primary hardware difficulties were the failure to survive power interruptions and sticky CDU keys. These problems were manifested on the CDU by a "lock-up" in which the system did not respond to any crew operation. The only solution was to "IPL"(Initial Program Load) the system. These problems were encountered throughout the evaluation, although they seemed to have been minimized by the end of the Pre-Service Approach Checks.

It is possible to consistently initiate good approaches if the complexities of the system are fully understood. Since the evaluation was limited to the two-segment approach capabilities of this system, a significant amount of effort in the latter stages of the Phase II evaluation involved developing a satisfactory technique for initiating use of the RNAV system relatively late in the flight, i.e. just before approach. This problem is discussed thoroughly in the "Procedures" section above.

One problem which can be forseen in the use of this system in regular airline service is that of troubleshooting the causes of unsatisfactory approaches. Many times during the evaluation only personnel with a detailed engineering knowledge of the system could determine the cause of aborts or unsatisfactory approaches - even then it sometimes took a few days to pinpoint the cause. The primary difficulty was determining if the situation was induced by an operational error, an inconsistency in the software, or failure of a hardware component. Late in the evaluation the RNAV software was modified to provide annunciation of a stored "abort code". This capability, with some further development, could ultimately prove invaluable in troubleshooting and fault isolation of systems as complex as RNAV.

Safety Protectors

The two-segment approach software included a variety of safety protectors to prevent the RNAV system from providing guidance in potentially unsafe situations.

The primary safety protectors ("aborts") are those developed in the B-727/ special purpose computer two-segment approach program. (These apply only to RNAV/ILS approaches). The flight director and autopilot guidance will be disconnected if the glideslope is not captured within: (a) a specific altitude above field level or (b) distance from touchdown corresponding to the location of the "Lower" waypoint. It has been pointed out that these two monitors are redundant and that in a production system only one should be required. Guidance system disconnect will also occur if the aircraft passes through the glideslope while armed to capture without actually capturing glideslope, or is providing upper segment guidance and is below glideslope for more than 10 seconds prior to being armed for capture. These safety protectors were tested during the flight evaluation by introducing an altitude error in the system by mis-setting the barometric pressure correction.

One additional safety protector was added for RNAV/ILS approaches. If the deviation from the localizer is greater than 2 dots when the system is armed for glideslope capture, the system will disengage. This protects against the situation where errors in navigation are of such a magnitude that the localizer is not within capture range when lateral control of the aircraft is passed to standard localizer tracking functions.

The above protectors are only effective for RNAV/ILS approaches. During the evaluation it was determined that an erroneous altitude input to the RNAV system (simulated by mis-setting the baro-correction) could result in unsafe vertical guidance being provided on an RNAV/RNAV approach. This must be kept in mind when considering the ultimate minimums to which RNAV/RNAV approaches may be flown.

The present philosophy regarding RNAV waypoint definition is that when the FAA defines a waypoint by bearing and distance from a navigation aid, the same navaid should be used when navigating to that waypoint regardless of the RNAV system's capabilities to use other navaids to define the same point in space. Accordingly, the system was designed to abort if the primary navaid (VOR and DME) for a particular set of approach waypoints is not tuned and valid for any 15 consecutive seconds. The time delay was originally set at 3 seconds, but this resulted in numerous disconnects due to short-duration radio cut-outs. As more experience with RNAV is attained, this abort could conceivable be revised to occur when navigation mode (e.g. DME-DME, DME-VOR, VOR-VOR, Air Data only) degrades below a pre-determined level. On RNAV/ILS approaches the primary VOR-DME does not need to be valid after glideslope capture, since both lateral and vertical guidance is fully dependent on ILS signals from that point to touchdown.

Component Failures

In addition to primary navigation radio monitoring, the ILS radio is monitored during RNAV/ILS approaches. The localizer must be tuned and valid when the system is armed to capture the upper segment (i.e. 8 n.m. from "Upper" waypoint) and glide-slope must be tuned and valid when the upper segment is captured. A message on the RNAV CDU to "Tune ILS" was included for RNAV/ILS approaches during the initial part of the evaluation, since the RNAV system does not auto-tune the ILS in the installation evaluated. This was later deleted because acknowledgement of the message was an added workload item and still did not assure that the ILS was tuned. Future installations could either incorporate such a reminder and have it cancelled automatically when the ILS is tuned or, more simply, include auto=tuning of the ILS.

The RNAV system also monitors true airspeed, indicated airspeed, altitude, barometric setting, and heading for valid inputs as a prerequisite to providing approach guidance. Internal RNAV system monitors are also incorporated. Simulated failure of each of these components was tested during the evaluation.

The results of all "aborts" are the same. In addition to the flags associated with the failed system being displayed, the navigation data on the HSI is flagged, the flight director steering bars are biased from view and the "FD" flag is displayed on the ADI the auto-pilot is disengaged if in use, and the approach progress display lights are extinguished. The corrective action for the crew is to pull the RNAV engage knob (course knob) on the HSI is restore the normal aircraft navigation systems interface. If the reason for the abort is not related to the ILS, a normal ILS approach may be completed. If the reason for the abort is cleared, the system still cannot be used for a flight director or autopilot guided approach if the aircraft has passed the upper segment capture point.

Enroute Operations

Although enroute use of the RNAV system was not part of the evaluation, nor certified for use in revenue service, several observations were made by the Project Pilot Team based on the out-of-service evaluations.

If the RNAV system couples the vertical and lateral axes together, such as the ANS-70A does, certain operational problems are encountered. During a climb profile it would be advantageous to allow the RNAV system control lateral navigation while letting the aircraft performance determine the most efficient climb profile. This climb profile cannot be predicted adequately to allow pre-programming it in the flight plan. Problems are similarly encountered during descent from cruise altitude.

In the terminal area the opposite capability would be advantageous. That is, allow altitude control by the RNAV system while being able to follow ATC vectors without updating the lateral flight plan. As mentioned earlier, the vertical speed command is not useful as an altitude hold because when altitude is lost or gained during maneuvering, flap extension, etc., the desired altitude is not re-attained when the vertical speed command is zero.

System Performance

RNAV/ILS Approaches

The RNAV/ILS approaches are consistantly accurate, precision approaches. These approaches should eventually be acceptable to Category II minimums, based on additional experience and demonstration of equipment reliability. This accuracy is attained by using the existing ILS signals and stabilizing the aircraft on the glideslope and localizer by 500' above the touchdown.

Early in the evaluation substantial problems were encountered in obtaining proper alignment with the runway, even when the ILS-localizer was being used by the RNAV system as part of the lateral navigation information. As a result of this problem, lateral control of RNAV/ILS approach is returned to the basic aircraft systems (autopilot and flight director localizer tracking) at the glideslope arm point, 5 miles from touchdown. The system was designed to use localizer as one of the lateral navigation inputs from the time "Upper" is the next waypoint until the glideslope arm point is passed.

RNAV/RNAV Approaches

The accuracy of RNAV/RNAV approaches varies widely from runway to runway, and even from day to day at a given runway. The primary reason for this variation is navaid inaccuracy. At both Stockton and Pueblo the primary navaid was positioned near (but not on) the centerline of one of the approaches. Those approaches which passed over the navaids (SCK 29R and PUB 25R) did not demonstrate the level of repeatability noted on the approaches which were headed towards the navaid for the entire approach. The navaid on the Pueblo runway 25 approach is only 2.1 miles from the end of the runway. When passing nearly directly over the transmitter, the radios would be invalid for a period of time, and the "primary navaid invalid" abort was experienced if they were invalid for 15 seconds. Approaches with similar navaid configurations should be evaluated carefully before being placed into regular service to avoid nuisance aborts.

The RNAV/RNAV approaches are non-precision approaches. All RNAV/RNAV approaches flown during the evaluation placed the aircraft in such a position that a visual landing could be made from 500 feet above touchdown. However, lateral displacements from the extended runway centerline of as much as 2000 feet at this point were experienced. The recommended minimums for the in-service evaluation are 800 feet ceiling and 2 miles visibility. This assures that the transition from the upper segment to the lower segment is made with the landing zone in sight so the pilot is able to plan any approach path modification necessary to complete the approach.

To emphasize that the RNAV/RNAV approach is a non-precision approach, the RNAV system disengages automatically as "Lower" waypoint is passed. The ILS receiver is also manually de-tuned so the glideslope flag in the ADI is displayed throughout the approach.

RNAV Data Base

Full flight checking of RNAV waypoint and navaid data bases is recommended based on the experience of the evaluation. Also, a high degree of quality control must be exercised in the production of digital data bases. Data base errors (wrong latitude, longitude, or type identification of stored waypoints or navaids, or wrong magnetic variation stored for a navaid) were encountered at Denver, Pueblo, Seattle, Vancouver, and Newark the first time the system was used in those areas.

The resolution of latitude and longitude to 1/10 arc minute is satisfactory for approaches, although it can result in courses from waypoint to waypoint in the approach which do not align precisely with the published inbound course. It may be advantageous to adopt some conventions in rounding exact lat-longs to the 1/10 arc minute which results in an aligned approach. Resolution greater than 1/10 arc minute does not appear justified based on the demonstrated accuracies of VOR and DME systems.

The Guest Pilot Evaluation was conducted immediately following the STC demonstration flights. The 31 pilots who participated are listed on the following page. Many of these pilots were not DC-8 qualified, but were asked to participate nevertheless to assure a broad spectrum of industry participation.

Since the evaluation environment of repeated approaches required certain system management artificialities, the Project Pilot with whom the guest had been paired in the simulator sat as First Observer and handled most of the RNAV flight plan programming. The pilot in the First Officer's seat flew the aircraft during the downwind leg while the Project Pilot programmed the next approach and discussed the previous approach with the guest pilot.

At the completion of the evaluation the questionnaires, which were filled out by guests after their simulator training session and after their evaluation flight, were compiled and tenative conclusions were drawn (Appendix F). A copy of the questionnaire is included on the following pages. In addition to this questionnaire, pilots were requested after their simulator session to rate the relative ease of operation of a number of items (Ref. Appendix F-8) and after their aircraft evaluation they were asked to judge the acceptability of several aspects of the two-segment approach (Ref Appendix F-10). The questionnaires and comments were analyzed and the conclusions were drawn using the same rationale as is detailed in the B-727 Guest Pilot Evaluation Report dated January 30, 1974 (NASA CR 137625). The compilation of comments and conclusions were provided to the guests for any further comments they wished to make. No additional comments were received. The final conclusions of the Guest Pilot Evaluation are as follows:

The two-segment profile and procedures were deemed acceptable for line operations provided (1) the pilots are adequately trained in the use of the RNAV system and in basic RNAV concepts (2) appropriate environmental constraints are applied to in-service operations in recognition of the limiting effects of certain environmental factors, and (3) equipment reliability and approach repeatability are improved. One of the guests felt the upper segment was too steep and lower transition was too low and abrupt for use in normal line operations, although he recommended in-service evaluation minimums as low as 400 feet ceiling - 1 mile visability (400-1). It also should be noted that this pilot was unable to have a simulator session prior to flying the approach in the aircraft.

The consensus was that the RNAV/ILS two-segment approach is a safe procedure, although conservative minimums should be used until the pilots are familiar with the procedure and equipment reliability is improved. The initial minimums established for the In-Service-Evaluation were 500-1, although the general opinion of the guest pilots was that the RNAV/ILS approach could eventually be used to lower minimums, including a considerable expression that it could ultimately be safe for Category II operations.

DC-8 PHASE II GUEST PILOTS

FAA

Oscar Berge
Lynn Mayfield
Ralph Noltemeier
Dick Skully

Airlines

American

Frank Nehlig
Al Reeser

Continental

Lee Lipsky
Carl Rogers

Delta

R. A. Byrd
Francis McDowall

Eastern

Charles Tennstedt

Flying Tiger

Dick Keefer

National

Roy Berube

Northwest

Don DeBolt

PSA

David Ferrell
Lowell Henderson

United

Howard Mayes
Lloyd Treece

Western

Dixon Carter

ALPA

Ralph Baxter, Western
O. M. Cockes, Eastern
W. P. Crowley, National
T. G. Foxworth, Pan American
Joe Harris, Trans World
Ray Lahr, United
R. N. Rockwell, Northwest
R. V. Studer, Delta
Gene Whitsitt, Braniff

Manufacturers

George Jansen, Douglas
A. W. LeVier, Lockheed
Brien Wygle, Boeing

The RNAV/RNAV approach is generally as acceptable as the current non-precision approaches. Vertical guidance through the initial approach segment is a desirable feature not presently available in non-precision procedures. However, the lack of accuracy and repeatability with respect to the lateral positioning result in the recommendation of ceiling minimums of 500-1000 feet, such as are typical for non-precision approaches. (Minimums of 800-2 were established for the In-Service Evaluation).

Although consensus of the guests was that the profile is safe, it is not regarded as easy to fly as the standard ILS with respect to following the flight director, instrument interpretation, and instrument scanning. In this regard there were a few specific comments which, although not incorporated into the system for In-Service Evaluation, could easily be made part of future installations. Among these were criticisms of the ILS glideslope flag display during RNAV/RNAV approaches, vertical deviation display switching from upper segment to glideslope, approach progress annunciation, and go-around guidance logic. Such differences in cockpit instrumentation and display philosophies are typical within the airline pilot community, and are readily accommodated by minor differences in systems as installed by individual airlines.

NAME_____ DATE_____

DC8/RNAV TWO-SEGMENT EVALUATION

GUEST PILOT QUESTIONNAIRE

☐ AIRCRAFT ☐ SIMULATOR

1. Is the Approach Progress Display meaningful and easy to interpret?

2. What changes, if any, would you recommend in the annunciation?

3. Is the ADI satisfactory? If not, why?

4. Is the HSI presentation acceptable? If not, why?

5. What is your opinion of the CDU presentation?

6. Would you recommend any changes in the instrument display? If yes, what changes?

7. What is your opinion of the transition to the upper segment?

8. What is your opinion of the transition to the lower segment?

9. Do you feel stabilized on the upper and lower segment ? Where do these points occur ?

10. Is the RNAV/ILS approach acceptably safe ?

11. To what minimums do you feel the RNAV/ILS can be flown ?

12. Is the RNAV/RNAV acceptably safe ?

13. To what minimums do you feel the RNAV/RNAV can be flown ?

14. How would you equate the RNAV/RNAV approach with the current day non-precision approaches, ie., (ADF, VOR, Back Course ILS) ?

15A. Do you feel the RNAV Two-Segment Approach can be flown in normal line operations ?

15B. What factors are involved in your answer to 15-A ?

LIST OF APPENDICES

Note:

Since the appendices are quite lengthy (over 100 pages), they are not provided with this copy of the report. Copies of the appendices are available from NASA-Ames or the UA Program Office.

LIST OF APPENDICES

APPENDIX A

Avionics Verification Flights Approach Log

The following notes from approaches chronicle the progress through the avionics verification portions of Phase II. Abbreviations used in these notes are listed below. Notes at the end of a series of approaches (a), b), c), etc) indicate general outcome of the respective test flight. These notes were taken from approach cards maintained in real-time by flight test personnel augmented by post-flight video tape reviews. Approach numbers not listed were approaches contemplated but not made due to equipment malfunction and/or operational error or approaches made without results significantly different from previous approaches.

A/C - Auto-coupled (Autopilot)
AG - Above ground
ANS - Area Navigation System
APD - Approach Progress Display
App - Approach
CDU - Control Display Unit
COAL - Waypoint name
DAM - Waypoint name
DME - Distance Measuring Equipment
DTW - Distance to Waypoint
F/D - Flight director
FF - Fuel flow
FRED - Waypoint name
G/S - Glide slope
HSI - Horizontal Situation Indicator
ILS - Instrument Landing System
IRNO - Reno Collocated DME
ISCK - Stockton collocated DME
KTS - Knots
K-102, K-106, K-109 - RNAV switching unit relays
LOC - Localizer
L/S - Lower Segment
MAP - Missed Approach Point
MSL - Mean Sea Level
NAV - Navigation
NM - Nautical Mile
OM - Outer Marker
pph - pounds per hour
PUB - Pueblo
RMI - Radio Magnetic Indicator
RNAV - Area Navigation
RN/RN - RNAV/RNAV
RNO - Reno
RN/ILS - RNAV/ILS (approach where RNAV used for U/S guidance ILS G/S for U/S)
ROSE - Waypoint name
SCK - Stockton
SEL - Select
SFO - San Francisco
STD - Standard (ILS)
U/S - Upper Segment
VOR - VHF Omni-Range

DC-8 TWO-SEGMENT APPROACH FLIGHTS

DATE	APP.#	MODE/TYPE	REMARKS
2/2/74			Maintenance Flight
2/2/74	5	A/C-2-seg	Raw data no guidance
	8	F/D-2-seg	#2 computer
	9	F/D-2seg	All lights green at same time
	11	F/D-STD	Good
2/5/74	13	F.D-2-seg	RN/RN High on U/S
	15	F/D-2-seg	Lateral steering not following path
	17	A/C-2-seg	RN/RN Too far right
	18	A/C-2-seg	Better tracking with SCK. SCK on CDU
	19	A/C-2-seg	RN/RN Vertical ok, lateral way right
	22	F/D-2-seg	RN/RN Vertical ok, lateral guidance poor. a) Must change "tune-ILS" acknowledge requirements. b) RN/RN waypoints are wide when close to ground. c) LOC tracking poor on RN/ILS - lots of oscillations.
2/6/74	24	F/D-2-seg	Turn-in to upper poor. Close waypoints are trouble when vertical NAV is involved.
	28	F/D-2-seg	Lateral tracking poor. Oscillatory on LOC.
	29	A/C-2-seg	Increased LOC gain 2½ times. No improvement. a) Localizer tracking unsatisfactory.
2/7/74	30	F/D-2-seg	Good turn-in, wide on LOC at G/S.
	31	F/D-2-seg	Vertical path too steep.
	34	A/C-2-seg	Heading sel mode inop if F/D in RNAV mode.
	40	A/C-2-seg	Not tracking profile properly
2/8/74	42	F/D-2-seg	Too steep. Right of path
	47	F/D-2-seg	Not turning in on LOC but left U/S too steep.
	50	F/D-2-seg	Better vertical, still not tracking LOC
2/9/74	52	A/C-2-seg	Delay G/S 10 sec. - trip.
	58	F/D-2-seg	RN/RN at RNO. 2000' left of LOC.
	59	A/C-2-seg	RN/ILS at RNO. Bend in profile.
	60	F/D-2-seg	Trip off at 1.4 DTW, 4950' on 500' AG
	61	F/D-2-seg	RN/RN - didn't acknowledge "tune ILS"
2/10/74	62	A/C-2-seg	Radio loss trip
	64	A/C-2-seg	60° intercept heading to upper - big LOC oscillations

DATE	APP.#	MODE/TYPE	REMARKS
2/10/74	69	A/C-2-seg	Lost approach due to "Tune ILS" message missed.
	71	A/C-2-seg	Straight-in approach still flies right of LOC.
	72	A/C-2-seg	Lateral oscillations spoiled lower transition.
	73	A/C-2-seg	LOC held steady then turned right at 1 NM. Lower transition was poor. a) Localizer tracking unacceptable b) Passing a waypoint at about 1 NM and getting a course change.
2/11/74	79	A/C-2-seg	Problem same
	85	A/C-2-seg	Big overshoot on U/S - went below G/S unsatisfactory. a) Lateral command unacceptable
2/13/74	89	F/D-2-seg	RN/RN at RNO off to left, and runway waypoint about 2000' down the runway.
	91	F/D-2-seg	RN/ILS Right of LOC with several course changes.
	97	A/C-2-seg	RN/ILS - IRNO-IRNO on CDU tracking still poor a) Weakening radio signals down low cause big errors in waypoints. b) LOC and G/S performance poor. c) Holding function of ANS-70 not working correctly.
2/15/74	109	F/D-2-seg	Pitch bar over-sensitive.
	110	F/D-2-seg	High speed and close waypoints produce poor navigation results. Each waypoint passage is a 270°-90.
	111	A/C-2-seg	Holding procedure ok, CDU labeling missing.
	114	A/C-2-seg	Lateral steering still oscillatory, upper transition has a knee type bend, going through G/S on lower transition.
	115	F/D-2-seg	Holding 200' left of centerline, upper transition poor.
	117	F/D-2-seg	LOC oscillations a) Lateral unacceptable. b) Transitions poor.
Switching unit modified so system switches directly to Lower Segment Amber.			
2/18/74	121	F/D-STD	Localizer deviation is reversed
	123	F/D-2-seg	DTW has a discontinuity 1.5-1.7-1.5
	124	F/D-2-seg	Base leg offset ok
	125	F/D-2-seg	Tailwind on approach 15 KTS FF 1500pph
2/19/74	130	A/C-2-seg	Headwind - F/D pitch down at lower amber. a) Waypoint incompatibility, ie. union too close to upper.
2/21/74	136	A/C-2-seg	Not on G/S until 200'.
	137	A/C-2-seg	APD lights too bright (night). No auto tune light.

DATE	APP.#	MODE/TYPE	REMARKS
2/21/74	138	A/C-2-seg	A/P help decreased 10% - control bump at L/S amber. a) Tracking poor on vertical profile.
2/22/74	144	F/D-2-seg	4° pitch-up command at lower capture
	146	A/C-2-seg	Autopilot good to 200'. F/D commands didn't agree.
	151	F/D-2-seg	RN/RN Poor accuracy. LOC full scale left at 7 NM. Using LOC as reference during RN/RN tracking. a) F/D transitions poor. b) RN/RN positioning of airplane poor. c) Not tracking glideslope after lower capture.
2/23/74	154	F/D-2-seg	Localizer tracking good.
	155	F/D-2-seg	Pitch down command at lower segment amber.
	156	F/D-2-seg	Localizer not stabilized by minimums.
	158	A/C-2-seg	Below glideslope after lower segment capture. a) Localizer tracking is not consistant.
2/26/74	167	A/C-2-seg	Poor LOC tracking. Duck under at lower capture.
	168	F/D-2-seg	Changed capture help - transiting smooth.
	170	F/D-2-seg	Not tracking glideslope.
	174	F/D-2-seg	Best approach into SFO 28L to date. a) System not significantly improving.
2/27/74	177	A/C-STD	Autopilot tripped at 680'.
	178	A/C-2-seg	Not tracking vertical very well following transitions. a) System still not significantly improved.
3/2/74	185	F/D-2-seg	2 Dots above glideslope at 100' on radio altimeter.
3/4/74	194	A/C-2-seg	Ailerons over active on autopilot.
	197	F/D-2-seg	Vertical deviation held up then suddenly dropped to one dot, abrupt lower segment capture. The vertical steering didn't bias up out-of-view passing the end of the runway.
	200	F/D-2-seg	F/D steering better to follow.
	203	A/C-2-seg	Course change to right following lower. a) APD lights too bright at night. b) ANS-70 system very complex and presents a big crew workload when it's flight plan is programmed in flight.

DATE	APP.#	MODE/TYPE	REMARKS
			c) Heading bug is tied to the system and moves around unnecessarily. d) The course from waypoint to waypoint inbound on a two-segment ILS shifts, ie. one or two degree changes. These should remain constant and be the ILS course. e) The No. 1 compass needle does not point to the "TO" waypoint. f) Localizer tracking very much improved.
3/5/74	206	F/D-2-seg	Pitch bar needs more damping.
	207	F/D-STD	No glideslope indicated on HSI.
	208	F/D-2-seg	1/3 dot left of localizer. At upper segment amber, this deviation came right out.
	209	F/D-2-seg	Overshoot on upper capture commands very slow to get back to upper segment. Airplane converges on lower capture point rather than getting quickly back on the upper segment.
	214	A/C-2-seg	Upper segment tracking better. Still not following glideslope.
	215	F/D-2-seg	First Officer can take control at about 500'AG, follow his F/D and be on G/S by 500' easily.
	218	A/C-2-seg	RN/RN About 2000' left of runway centerline at 500' AG.
	219	A/C-2-seg	RN/RN The waypoints appear to shift around as the airplane gets to lower altitudes.
3/6/74	220	F/D-2-seg	No pitch tracking.
	224	A/C-2-seg	Vertical deviation jumps after upper green.
3/7/74	225	F/D-2-seg	Steering commands better.
	228	A/C-2-seg	Appears to hold fixed attitude on G/S, rather than tracking the signal.
	229	F/D-2-seg	Localizer commands good.
	230	A/C-2-seg	System trip off at upper segment green because we failed to tune the #1 radio to the proper ILS frequency.
3/10/74	231	F/D-2-seg	Base leg offset not working.
	233	F/D-2-seg	Abused approach. Late pushover on upper transition. The system converged on the upper segment as it approached lower which resulted in essentially a steeper upper segment.

DATE	APP.#	MODE/TYPE	REMARKS
	234	F/D-2-seg	Using a +10 knot increment on the upper segment and bleeding it off in the lower transition increases the pilot workload.
	235	A/C-2-seg	Went below G/S. The vertical command bar on the flight director biases out of view now when go-around is selected. a) Localizer tracking is much improved. b) Airplane not following glideslope after lower capture. c) RN/RN accuracy below 500'AG is poor.
3/11/74	242	F/D-2-seg	14 knot tailwind, upper transition ok - good tracking.
	243	F/D-2-seg	Flying off profile and then following F/D produced good results, ie., corrected immediately back to upper segment.
	245	F/D-2-seg	180 knot entry ok. #1 DME breaker pulled after lower green. System did not abort.
	246	F/D-2-seg	"DIRECT TO" functioned. High speed intercepts produced 1½ dot high stand-off on upper segment.
	248	F/D-2-seg	Made a 270°/90° turn-in and tripped off.
	249	F/D-2-seg	Increasing airspeed during upper transition produced a 1 dot overshoot. Once back on upper segment, tracking ok. The airspeed was bleed off during lower transition and this appeared to be ok.
	252	F/D-2-seg	RN/RN Path is left of runway centerline.
	254	F/D-2-seg	Direct to "upper" produces poor lateral tracking.
	255	A/C-2-seg	Autopilot will fly 190 KTS upper transition but the F/D will not follow it. Airspeed bleeds are no problem in following vertical path - workload has some impact.
	256	F/D-2-seg	RN/RN Flying off profile and then correcting back degrades system performance. Vertical deviation indicator goes off scale at 2 dots and then comes in low, ie., 3 dots high is 1 dot low indication on HSI. 4 dots high reads as zero. 5 dots high as one dot high.
	258	A/C-2-seg	Very good performance on enroute and approach flown from SCK to SFO on RNAV. Letting the system do the flying produces good results.

DATE	APP.#	MODE/TYPE	REMARKS
3/12/74	262	F/D-2-seg	RN/RN using ISCK, ISCK. Good approach.
	263	F/D-2-seg	MAP waypoint looked short, good approach.
	268	A/C-2-seg	Baro Altimeter misset low for evaluation - as advertised.
	269	A/C-2-seg	Baro Altimeter misset high - as advertised - reversion to STD system just takes a couple of seconds.
	270	A/C-2-seg	RN/RN use of "DIRECT TO" locked up system.
	272	A/C-2-seg	Autopilot will not engage after upper capture once it has been disconnected.
	273	A/C-2-seg	RN/RN guidance takes you right to MAP where system goes to go-around mode. (Pilots don't like flying down to ground on autopilot and the runway not at touch-down spot.)
	274	A/C-2-seg	RN/RN - Pilot prefers constant speed - DME's failure as advertised.
	275	A/C-2-seg	RN/RN - Code failure as advertised, dis-engage warnings as advertised.
	276	A/C-2-seg	Glideslope failure as advertised.
	277	A/C-STD	Flying approach with RNAV system on but no auto tune - as advertised.
	278	A/C-2-seg	180 KTS to OM acceptable, can slow to approach speed prior to lower transition. a) System greatly improved. b) Engineering function of the protection is correct. c) RNAV/RNAV guidance to the surface looks like a dangerous practice. d) System operation is not consistant. e) Operational procedures ok but system is not ready for Guest Pilots yet.
3/13/74	279	F/D-2-seg	200KTS intercept - difficult to slow down .
	281	F/D-2-seg	Anti-icing evaluation - manifold temp below 158°C for 1 min, 15 seconds during approach. Good results.
	282	F/D-2-seg	Lower segment abuse - F/D put airplane back on profile - 360° turn prior to upper messed up the upper capture - pilot needs to follow guidance as programmed.
	283	F/D-2-seg	Adjusting baro on U/S shifts airplane guidance up and back. Adjustments on lower segment has no effect.
	284	Raw data/2-seg	No APD. Small lateral deviation jump as Union waypoint was passed and upper the next waypoint. (The localizer comes into the calculations here and the deviation switches to localizer) Lower transition was ok - past experience was sufficient to start it - drifted off LOC as attention was on vertical profile.

DATE	APP.#	MODE/TYPE	REMARKS
	286	F/D-2-seg	RN/RN wind shift 090/18 to 300/10 in 0.3 NM. System handled it ok.
	287	F/D-2-seg	RN/RN 20 KT tailwind - thrust idle on U/S.
	288	F/D-2-seg	RN/RN 360° turn after upper segment green produces a big error on U/S (2 dots high) but slowly correcting such that system was correct at 1.5 NM. a) System correct as designed. b) Pilot must follow programmed path in order to get a good approach. c) System still complicated and not consistant. d) MAP should be reprogrammed to the runway touchdown point.
3/14/74	303	F/D-2-seg	Inserted the approach behind the wrong waypoint - very easy to make a flight plan error when operating CDU in the terminal area.
	304	A/C-2-seg	LOC transmitter shut down on ground - as advertised.
	305	A/C-2-seg	G/S transmitter shut down on ground - as advertised.
	306	A/C-2-seg	DME transmitter shut down on ground - as advertised.
	308	F/D-2-seg	A long track offset ok.
	309	A/C-2-seg	RN/RN - MAP drifted right 600'.
	310	F/D-2-seg	RN/RN - guidance makes a course change at each waypoint. At low altitude, waypoints appear to drift.
	313	A/P-2-seg	Simulated failure hard-over nose down - is easily recognized and recovered.
	314	F/D-2-seg	Severe turbulence at RNO - difficult to operate CDU, easy to fly upper segment.
	315	F/D-2-seg	Overshoot on upper transition - had to use idle thrust.
	316	F/D-2-seg	RN/RN - Steep and to left of centerline.
	318	A/C-2-seg	RN/RN - Path crossed centerline left to right.
	319	A/C-2-seg	RN/RN - SFO 28L profile shifted out short and to right. a) RNAV/RNAV geometry moves around as a function of radio locations and altitude above ground (signal strength). b) SCK, SFO, RNO approaches are more consistant. c) Data base errors greatly affect the approach path.

Following approach 324 on 3/16/74, the airplane was moved to Denver for the Guest Pilot Evaluation.

DATE	APP.#	MODE/TYPE	REMARKS
3/17/74	325	A/C-2-seg	First Pueblo approach for data base check - 20 knot tailwind - forgot to tune ILS frequency prior to upper segment green.
	326	A/C-2-seg	DAM waypoint incompatible with the approach. Abort.
	327	A/C-2-seg	Moderate turbulance - 20 KT tailwind - CDU difficult to operate. Went below G/S after lower segment capture.
	328	F/D-2-seg	RN/RN profile bent right and short 7L.
	330	A/C-2-seg	RN/RN 400' right of runway at lower 25R.
	331	A/C-2-seg	Overshoot on localizer on turn-in. Dot waypoint has big data base error.
	333	A/C-2-seg	Highspeed entry with tailwind - overshoot on upper segment. F/D has difficulty - it doesn't give sufficient command.
	334	A/C-2-seg	26L at Denver - data base MAP is 1500' down the runway - the shift-in was almost to cause a 500'AG trip-off.
	335	A/C-2-seg	RN/RN - Ranch waypoint incompatable - good approach.
	336	A/C-2-seg	Golf 3 waypoint in error. Good approach 35.
	337	A/C-2-seg	RN/RN 35 Autopilot disengaged at upper - continued on F/D. a) Every waypoint needs to be flight checked for accuracy. b) MAP waypoint should be moved to touch-down. c) Approach profiles again shift according to ground radio transmition locations. d) System operation is not consistant.
3/19/74	339	A/C-2-seg	RN/RN - "DIRECT TO" upsets system-when APD lights go out the approach is dropped and must be re-entered.
	340	A/C-2-seg	Cannot use offset when one of the way-points is upper.
	345/348	F/D-2-seg	Guest Pilot Syllabus development.
	349	A/C-2-seg	"DIRECT TO" messed up system - reverted to STD.
	350	A/C-2-seg	High speed entry - F/D wouldn't follow.
	351	A/C-2-seg	Good approach except DTW reached 1.8 prior to G/S green and system tripped. a) System not consistant. b) Waypoint within 1 NM of upper is a problem. c) "DIRECT TO" still not any good. d) Data base must be checked for every approach. e) High speed entrys are no good. f) MAP waypoint should be programmed to touchdown.

DATE	APP.#	MODE/TYPE	REMARKS
3/20/74	352	F/D-2-seg	Captain G. Brown's first evaluation prior to Guest Pilots.
3/21/74	356	A/C-2-seg	Captain H. Mayes first evaluation prior to Guest Pilots. Wind sheer on this approach to 7L, was 270/35 at 9000' to 260/4 at the surfase. The throttles were closed during the upper transition and on the upper segment. The airspeed stabilized at about 160 KTS. The airplane made the lower transition with very little undershoot of the G/S and was stabilized by 500'AG.
	359	F/D-2-seg	Winds at Denver were 312/20 at 6200 '. The data base was such that the airplane reached 500' prior to glideslope capture and the system tripped off.
3/22/74	360	A/C-2-seg	Auto throttle system holding 3-4 kts below bug speed. Autopilot trips intermittently. #1 RMI needle is now pointing to the "TO" waypoint.
	361	A/C-2-seg	The "DIRECT TO" function operated ok.
	362	F/D-2-seg	The F/D pitch command bar is more sensitive but the upper transition is better as the F/D commands the airplane to get on the upper segment quicker following a vertical deviation.
	365	A/C-2-seg	Transition to upper segment didn't start until the upper segment centered on the HSI. One dot right of LOC until lower segment amber then it centered. Program changed to update the wind information at a higher rate into the approach.
	367	A/C-2-seg	Good approach.
3/23/74	369	A/C-2-seg	Data base error in waypoint locations.
	370	F/D-2-seg	Vertical event with present altitude occurs when "DIRECT TO" is used. This provides a problem that doesn't clear until the next waypoint is passed. "DIRECT TO" upper produces a lock up - "DIRECT TO" other waypoints ok.
	371	F/D-2-seg	Better tracking.
	372	F/D-2-seg	Using heading command turned to a heading that would fly airplane inside upper to capture the final approach course. System lock-up occurred - would not fly it.
	373	F/D-2-seg	Icing conditions 8 knot crosswind - no

DATE	APP.#	MODE/TYPE	REMARKS
			indications of ice anywhere except on right windshield. Approach ok.
	324	A/C-2-seg	Icing conditions - manifold temp on initial was 135°/152° on upper segment at 6400'MSL, 130°/140° outside air temp was -6°C. Right windshield heat was turned off - 1/2 inch ice formed on right windshield. No other ice observed or detected on airplane.
	375	A/C-2-seg	Wind patch out - waypoints appear to shift, ie., lower and touchdown waypoints wide of localizer.
	376	A/C-2-seg	Wind patch in - better waypoint positioning on RN/RN approach. Airplane 500' right, 1000' short at MAP.
	377	A/C-2-seg	10 KT tailwind - good approach.
	380	F/D-2-seg	RN/RN - pitch bar jittery. Unhappy with this.
	383	A/C-2-seg	ATC changed the approach from 26 to 35 when we were within 15 miles of the airport. It took full attention to the CDU and head down for 2-1/2 minutes to change the flight plan.
	384	F/D-2-seg	Forgot to tune ILS system - aborted at upper green - immediately reverted to STD ILS, descended and salvaged the approach.
	385	A/C-2-seg	Jitter gone from the F/D pitch bar.
	386	F/D-2-seg	System tripped off at 2.1 DTW - reverted to STD ILS and successfully completed the approach.
	387	A/C-2-seg	RN/RN - highspeed entry overshot upper segment by 2 dots. Tested the K-104 failure.
	388	F/D-2-seg	RN/RN - highspeed entry - +30 acceleration to 180 KTS. This time the F/D handled it.
	389	F/D-2-seg	Tested K-102 failure.
	390	A/C-2-seg	Highspeed entry (180 KTS). F/D followed ok.
	391	F/D-2-seg	215 KTS entry - 1/2 dot overshoot on upper segment.
	394	A/C-2-seg	APD lights dropped off at upper segment green, base leg off-set from COAL to FRED used along track off-set for altitude. System indicated a vertical event sequencing abort. Completed a visual approach and went around.
	395	A/C-2-seg	Repeated approach without offsets - good approach.

DATE	APP.#	MODE/TYPE	REMARKS
3/24/74	396	A/C-2-seg	Used along track off-set-system aborted.
	397	A/C-2-seg	Autothrottle ok.
	398	A/C-2-seg	Poor approach both laterally & vertically.
	403	F/D-2-seg	Approach better if 2 waypoints are passed on flight path prior to upper.
	407	A/C-2-seg	Autopilot performance now acceptable. F/D still not good.
	409	A/C-2-seg	Tested K-109 failure.
	410	A/C-2-seg	Tested K-106 failure then K-205 enroute to Denver.
	411	A/C-STD	Good approach, standard system unaffected.
	412	A/C-2-seg	Lost approach for failure to tune ILS. Reverted to standard - good STD ILS approach.
	413	F/D-2-seg	Tested K-109.
3/25/74	414	A/C-2-seg	Wind patch not in - 3/4 dot undershoot G/S.
	415	A/C-2-seg	LOC transmitter failure - as advertised.
	416	F/D-2-seg	Autocoupler would not engage - system flew upper segment only - tripped at lower.
	417	A/C-2-seg	RN/RN - Good approach.
	420	A/C-2-seg	CDU lock-up (lots of button pushing).
	422	A/C-2-seg	20 KT tailwind - marginal operational
	425	A/C-2-seg	Trip put to LOC & G/S fault.
	427	A/C-2-seg	RN/RN - abused approach - turned in close. If final approach waypoint is close to upper, it makes a poor turn-in. Flown low of intercept altitude with rate-of-descent, the system then leveled off until the upper segment deviation centered, then commanded the airplane to follow the path. (Transitions this way are poor.)
	428	A/C-2-seg	Autocoupler good to low altitude - 20' above surface.
	429	A/C-2-seg	Accellerated to 200KTS in transition. F/D could not follow.

a) System not reliable enough for line operation.
b) Upper transition cannot tolerate high speed or altitude errors of any large magnitude.
c) MAP waypoint needs to be reprogrammed to touchdown.
d) "DIRECT TO" function not working right.
e) Data base at Pueblo has lots of errors.

ENGINEERING EVALUATION FLOWN DURING GUEST PILOT EVALUATION

3/29/74	NO. 494 - A/C-2-segment	System goes to "Go-Around" mode as the MAP waypoint is passed - except the APD Go-Around Light doesn't work.
	NO. 501 A/C-2-segment	RN/RN - On PUB 25R, the system disengaged at 560' as it passed close to the VOR. The DME signal went invalid then when the VOR signal went invalid, the system disengages. On an RN/RN approach, the vertical steering will be removed passing lower anyhow so this doesn't present a problem. It does point out a problem in passing close to or over a VOR when on an RN/RN approach.

APPENDIX B

TYPE INSPECTION AUTHORIZATION

TIA T5315WE-DS

This is a copy of the FAA document describing the tests and inspections deemed necessary to approve the use of the RNAV equipment to perform two-segment approaches in revenue service.

TYPE INSPECTION AUTHORIZATION

PAGE 1 OF 6 PAGES

PROJECT NO. T5315WE-DS-

TO: [X] FLIGHT AWE-160 (Routing Symbol) [X] MANUFACTURING AWE-180 (Routing Symbol)

DATE MAR 22 1974

NAME OF APPLICANT: United Air Lines

ADDRESS (Number, street, city, state, and ZIP code): International Airport, San Francisco, Calif. 94128

1. INSPECTION AUTHORIZED FOR

X	AIRPLANE	OTHER (Specify)		NEW MODEL (Give model no.)	
	ENGINE				
	PROPELLER			ALTERED MODEL (Give name of original manufacturer and model no.)	ORIGINAL T.C. DATA SHEET NO.
	ROTORCRAFT		X	McDonnell Douglas DC-8-61	4A25

2. CERTIFICATION BASIS

CAR 4b dated December 31, 1953, with amendments and special conditions described on T.C. Data Sheet No. 4A25

3. CATEGORY–FOR AIRCRAFT ONLY (Check all applicable items)

	NORMAL		UTILITY		ACROBATIC	X	TRANSPORT		RESTRICTED		OTHER (Specify)

4. DESCRIPTION OF ALTERATION

Installation of R NAV Equipment to perform Two-Segment Approaches

5. DESIGN SPEEDS - MPH (EAS) – SEE PAGE *	6. MAXIMUM MACH NO. (DESIGN) – SEE PAGE *	7. DESIGN WEIGHTS – SEE PAGE *
8. MAXIMUM OPERATING ALTITUDE (Feet) *	9. MAXIMUM CABIN PRESSURE DIFFERENTIAL (p.s.i.) *	10. CG. LIMITS – SEE PAGE *
11. CARGO AND BAGGAGE COMPARTMENTS - LOCATION AND MAXIMUM LOADS – SEE PAGE *	12. STRUCTURAL/MANEUVERING LIMITS – SEE PAGE	

13. OPERATION LIMITATIONS

ENGINE MAKE AND MODEL (FOR TURBINE ENGINE SEE PAGE) | ENGINE DATA SHEET NO.

ITEM	ON TAKEOFF (Specify) (Minutes)	LOW RATIO SUPERCHARGER: SEA LEVEL	LOW RATIO SUPERCHARGER: ALT. HEIGHT (Specify) (Feet)	HIGH RATIO SUPERCHARGER: ALT. (MIN) (Specify) (Feet)	HIGH RATIO SUPERCHARGER: ALT. (MAX) (Specify) (Feet)
IN. HG.					
RPM					
HP					

MAXIMUM ALLOWABLE TEMPERATURE		°F.
CYLINDER HEAD (OR COOLANT OUTLET)	WASHER	
	BAYONET	
CYLINDER BASE		
OIL INLET		
MINIMUM CARBURETOR HEAT RISE REQUIRED AT ____ % MC POWER		

14. PROPELLER N/A

MAKE AND MODEL	DATA SHEET NO.	DIAMETER
HUB MODEL NO.	BLADE MODEL NO.	LIMITATIONS – SEE PAGE

15. ROTORCRAFT N/A	MAXIMUM	MINIMUM
POWER ON ROTOR LIMITS–RPM		
POWER OFF ROTOR LIMITS–RPM		

16. INSPECTION REPORT		
100-HOUR INSPECTION COMPLETED		YES
		NO

17. EQUIPMENT LIST		
IS EQUIPMENT LIST CORRECT AS TO WEIGHT AND ARM OF EACH ITEM	X	YES
		NO
EQUIPMENT LIST ATTACHED	X	YES
		NO
MFGR. REPORT NO.		

18. TYPE INSPECTION REPORT	
X	COMPLETE APPLICABLE PORTIONS OF TYPE INSPECTION REPORT, PART 1
X	COMPLETE APPLICABLE PORTIONS OF TYPE INSPECTION REPORT, PART 2
X	SEE ATTACHED PAGES FOR INSTRUCTIONS
X	SEE ATTACHED PAGES FOR SPECIAL TESTS (Define divisions of responsibilities)

ORIGINATED BY	CONCURRENCES					
ROUTING SYMBOL	ROUTING SYMBOL	INITIALS	ROUTING SYMBOL	INITIALS	ROUTING SYMBOL	INITIALS
AWE-130	AWE-120	[illegible]	AWE-140	[illegible]	AWE-160	[illegible]
	AWE-130	[illegible]	AWE-180	[illegible]	AWE-270	[illegible]

APPROVAL

DATE 3/22/74 TITLE Acting Chief, Aircraft Engineering Division SIGNATURE [signature]

This TIA describes the inspections and tests that must be completed prior to the approval of the subject modification in a McDonnell Douglas DC-8-61 airplane. This modification installs equipment to provide vertical and lateral guidance to the Z-5 Flight Director and the SP-30AL autopilot to conduct two-segment approaches.

NOTES:

(1) The following is a list of major components associated with this modification:

(a) Switching Unit - Collins P/N 161E-12
(b) Control Display Unit - Collins P/N 813H-1C
(c) Navigation Computer - Collins P/N 8564B-2X
(d) Flight Data Storage Unit - Collins P/N 8848D-2
(e) Magnetic Tape Unit - Collins P/N 7520A-1
(f) Diode Box - Collins P/N 621-8612-001

(2) The equipment involved in this modification consists basically of a Collins ANS-70A area navigation system which provides lateral and vertical guidance through the existing Captain's flight director and the autopilot. The Co-Pilot's instruments remain unchanged.

(3) The software computer program tape to be used for these tests is Collins P/N 10838900.

18A. The Manufacturing Inspection Branch is requested to:

1. Conduct a conformity inspection in accordance with United Air Lines Report Number F-1665 "A" revision dated March 20, 1974 (installation only).

2. Obtain from the applicant a statement of conformity, covering the modification involved, FAA Form 317, indicating compliance with FAR 21.33.

3. Obtain a current weight and balance report.

4. Conduct any other inspections deemed necessary.

18B. The Flight Test Branch is requested to conduct the following flight tests, and record all results:

1. Perform functional flight tests to confirm normal operation of the following systems:

   #1 DME system (using read-out on HSI)
   #1 Compass system
   #1 Horizon system
   #1 VOR
   #1 ILS (localizer and glide slope)
   #1 Flight director
   Autopilot

2. Perform an RNAV/ILS two segment approach using #1 flight director and autopilot. Check that the airplane is commanded to fly the programmed approach path and that the approach annunciator lights illuminate in the proper sequence.

3. Perform an RNAV/RNAV two segment approach using #1 flight director and autopilot. Check that the airplane is commanded to fly the programmed approach path and that the approach progress annunciator lights illuminate in the proper sequence.

4. During a two-segment coupled approach, check that the loss of validity of the #1 CADC or Captain's compass system causes the autopilot to disengage, the #1 flight director steering bars to driven from view, the Captain's HSI to be flagged, and the approach progress display light to extinguish.

5. During a two-segment (RNAV/ILS) coupled approach check that loss of validity of the ILS signals after upper segment capture will cause the autopilot to disengage, the #1 flight director steering bars to be driven from view, the HSI to be flagged, and the approach progress display lights to extinguish.

6. During a two-segment coupled approach (RNAV/ILS), check that while flying on the upper sigment only, loss of validity of the #1 VHF NAV receiver, #1 DME or #3 DME interrogator, will cause the autopilot to disengage, the #1 flight director command bars to be driven from view, the HSI to be flagged, and the approach progress display lights to extinguish.

7. During a two-segment coupled approach (RNAV/RNAV) check that while flying on the lower segment loss of validity of the #1 VHF NAV receiver, #1 DME or #3 DME interrogators will cause the autopilot to disengage, the #1 flight director command bars to be driven from view, the HSI to be flagged, and the approach progress display lights to extinguish.

8. With the RNAV on check that the autopilot HEADING SELECT and TURN KNOB modes can be selected but that positioning the mode selector to LOC/VOR or ILS will cause the autopilot to disengage.

9. With the RNAV "on" check that the #1 flight director can be operated in the Flight Instrument mode and that positioning the mode selector to VOR/LOC or APPR will cause the command bars to be driven from view.

10. Turn the RNAV system on with instructions to compute a two-segment approach but without selecting RNAV with the flight director or AUX NAV with the autopilot. Check that after passing the UPPER capture point, attempting to select RNAV with the flight director will cause the command bars to be driven from view and attempting to select AUX NAV with the autopilot will cause the autopilot to disengage.

11. Determine whether the brightness of the display lighting under all normal types of cockpit ambient lighting conditions is satisfactory.

12. Determine whether the vertical deviation presentations provide adequate information to safely control the airplane throughout the two-segment approach.

13. Determine whether the mode annunciation provided by this modification is adequate and satisfactory for conducting two-segment approaches.

14. Determine whether the failure warning indications, cues and any other aspects as presented to the pilot are adequate for conducting two-segment approaches.

15. Determine whether the #1 flight director is satisfactory to conduct go-arounds.

16. Determine whether satisfactory ILS manual and coupled approaches and go-arounds can be conducted with the RNAV system turned off.

17. Determine whether this system can perform satisfactory two-segment approaches under various wind conditions.

18. Determine whether this modification can adversely affect any other systems or equipment installed in the airplane and vice versa. Include operation of the recirculation fan "on" and "off" and ADF in this evaluation.

19. Determine whether the cockpit modifications associated with this TIA are satisfactory.

20. Evaluate the ability of the flight crew to change or correct an assembled flight plan to conduct a two-segment approach.

21. Determine whether a satisfactory means exists for the flight crew to determine whether the correct program has been inserted in the computer.

22. Conduct coupled and manual two-segment approaches at forward and aft center of gravity, heavy and light weight, using different flap settings if appropriate, and different approach speeds as appropriate. Evaluate each condition and record all results.

23. Conduct a nose down autopilot hardover while the airplane is still on the upper segment of the approach. This test should be conducted at aft c.g., and light weight. Record the radio altitude to obtain the altitude loss deviation profile. The pitch channel automatic cut-off should be deactivated for this test and allow one second after pilot recognition of the malfunction prior to initiating appropriate corrective action.

24. Simulate the following relay failures in the switching unit during flight tests. Evaluate and record all results.

(a) K102 (erratic or missing autopilot pitch movements)
(b) K104 (erratic or missing vertical deviation to HSI)
(c) K106 (DME & NAV 1 frequency not properly tuned)
(d) K109 (lateral axis switching within 4.8 NM of runway)
(e) K205 (unreliable command bars)

25. Evaluate the flight crews' ability to continuously monitor the aircraft condition during the two-segment approach.

26. Determine whether adequate means exist for the crew to monitor which ground stations have been selected by the autotuning signals from the RNAV equipment.

27. Simulate a condition which would place the "UPPER" waypoint two miles closer to the airport than it should be. Evaluate this condition both with a normal barometric altimeter setting and with a mis-set barometric altimeter setting, and record the results.

28. While flying and prior to reaching the "UPPER" waypoing simulate power interruptions to the RNAV computer as follows:

(a) 1½ seconds
(b) 3 seconds
(c) 2½ minutes

Evaluate and record the results.

29. Simulate a condition that is the result of worst case tolerances in the equipment and will result in the steepest first segment angle. Evaluate and record the results.

30 During the two-segment flight tests, evaluate as many as possible of the protections provided by this system which are intended to prevent an unsatisfactory t segment approach. Record all results.

31. Determine whether the AFM supplement for this modification is satisfactory.

32. Evaluate various approach geometries i. e., intercept angles, speeds, initial altitudes above field, etc., and record all results.

33. While conducting flight director two-segment approaches, determine whether the presentations are satisfactory at the transition points to and from the upper segment portion of the two-segment approach. Record all results.

34. Conduct any other tests deemed necessary.

APPENDIX C

Narrative of STC Flight Tests

The three STC flights were flown March 26 and 27, 1974. The flights originated and terminated at Stapleton Field, Denver, Colorado with an enroute to and from Pueblo Airport.

The following table summarizes the STC approaches.

APPROACHES	PUB 7L	PUB 25R	DEN 26L	DEN 35	TOTALS
STD ILS Autocoupled	2				2
RNAV-ILS Autocoupled	13	3	1		17
RNAV-RNAV Autocoupled	2	1			3
RNAV-ILS Raw Data	1				1
RNAV-ILS Flight Director	3	1		1	5
RNAV-RNAV Flight Director		2			2
Totals	21	7	1	1	30

TABLE I

The first flight had a forward C.G. of 25.4% and a gross weight of 240,000 lbs. The second flight had an aft C.G. of 27.4% and a gross weight of 204,000 lbs. The third flight's C.G. was Mid, 26% with a gross weight of 243,000 lbs.

Flight Number 1

The ANS-70A system was loaded with non-editable tape P/N 10838912. The taxi and takeoff was made with auto-tune off. The #1 Flight Director functioned normally in the F/I and VOR/LOC modes during the takeoff and climb out to KIOWA. Passing KIOWA, the #1 VHF NAV was tuned to Pueblo 116.7 and the Pueblo identifier was verified. The CDU was programmed for the route, and approach to Pueblo. The auto-tune switch was turned on and the system was checked for operation.

The auto-tune was selected and the Distance to Waypoint indicated the distance to HOVER (HOVR1). The autopilot was engaged in the TURN KNOB mode and functioned normally in that mode. Heading (HEADING SELECT) mode functioned normally. When the VOR-LOC mode was selected and the autopilot disengaged, the autopilot would not engage in the ILS mode. The autopilot was re-engaged and the flight director mode switch moved to RNAV. HEADING SELECT mode was selected and the autopilot disengaged. The AUX-NAV position was selected and held while the autopilot was engaged. The airplane was coupled to the RNAV path in course and altitude to HOVER. At HOVER waypoint, which is Hanover intersection, the latitude-longitude was checked and found to be within 0.1 minutes as indicated on the "Present Position" page of the CDU, when the #2 VOR/DME indicated the airplane was at Hanover. The airplane descended to 9000' MSLand continued to ROSE (ROSE 9) and EDEN5/255°/3.1 (bearing distance) waypoints. The RNAV APPROACH light illuminated amber just past ROSE and turned green at about EDEN.

The approach selected was the RNAV/ILS to Runway 7L. The final approach waypoint was UPPER/255°/3 (bearing distance). The surface wind was reported to be 280°/14 KTS, the temperature, 60°F. The airplane gross weight was235,000 lbs, the reference speed 143 KTS. The #1 VHF-NAV control head was tuned to 109.5, the 7L localizer frequency. The wind as indicated on the "Present Position" page, was a 20 knot tailwind. Soon after EDEN was passed, the UPPER SEGMENT light illuminated amber. The vertical deviation switched to the upper segment and moved up out of view. The turn-in onto the final approach course had a small overshoot but was tracking straight and level on course as the UPPER SEGMENT light turned green and the transition to the upper segment commenced. The flaps were at 25° and the airspeed 170 KTS. The gear was extended and the throttles retarded to idle. The flaps were extended to 35° when the gear indicated down and then to 50°. The airplane was centered on the upper segment and about 1/4 dot right of the ILS localizer centerline when the LOWER SEGMENT light illuminated amber at 4.9 distance to waypoint (DTW). The throttle was advanced slightly to hold air speed. The slight localizer deviation converged to centerline. The airplane tracked the upper segment very well down to 5550' where the LOWER SEGMENT light turned green. The lower transition started and the airplane was steady on the glide slope at 5200' MSL (532' above touchdown zone). The airplane tracked the localizer and glide slope closely to 100' ATZ where the autopilot was disengaged. The flight director was flown to the runway threshold. At this point, the flight director pitch bar biased up out-of-view, the Approach Progress Lights extinguished, and the GO-AROUND light illuminated. The lateral steering bar of the flight director provided guidance to the far end of the runway. After passing the far end of the runway, the ANS-70A system reverted to enroute operation and the next waypoint was ROSE 9.

Prior to the second approach, a series of extra waypoints and the 25R RNAV-ILS were entered. Entry of a second approach to 7L was attempted and was rejected by the ANS-70A system since only one two-segment approach can be entered at any one time.

The second approach flown was a Flight Director. RNAV/ILS to 25R. Therreported wind was 280°/15 KTS. Airplane gross weight was 232,000 lbs, and Vref 142 KTS. The pilot flew the flight director commands very closely. The airplane airspeed was 200 KTS IAS on the 90° turn-in to final approach course. The airplane overshot the localizer centerline about 1 dot and was at this deviation at upper segment capture (UPPERSSEGMENT green). The localizer deviations from that point were insignificant. The "Present Position" page indicated a headwind of 18 KTS. The lower capture occurred at 5400' MSL (150 KTS IAS), and the airplane was on the glide slope by 500' AG. At 0.3, distance to runway threshold, the GO-AROUND button was pressed. The flight director went to "GO-AROUND" as when passing the runway threshold. During this approach, the Co-Pilot was able to monitor the airplane position and determine the position by reference to his instruments as well as cross-check the Pilot's instruments. At 1000' AG, the Co-Pilot could determine that the Pilot's ADI glide slope indication agreed with the Co-Pilot's and that the Pilot's HSI vertical deviation was centered on the upper segment. (Lower segment AMBER annunciation.) At 500' AG, the Co-Pilot could determine that all vertical deviation indicators were in agreement. (Airplane on glide slope.) The airplane was flown to ROSE 9 waypoint by the Co-Pilot, using the #1 VOR needle which points to the "TO WAYPOINT" and verifying it by bearing/distance from the Pueblo VOR.

The third approach flown was an RNAV/RNAV autocoupled approach to R/W 25R. The reported wind was 290°/15 KTS, gusts to 20KTS. The airplane gross weight was

226,000 lbs. and Vref 140 KTS. The RNAV/RNAV approach was entered and the #1 VHF radio tuned to PUB VOR (116.7). The CDU waypoint title lines indicated the approach to be 25RNB (RNAV/RNAV) and the glide slope flag in the ADI was in view. There was very little overshoot in the turn-in to final approach course. The inbound track appeared aligned with the centerline. The lower capture occurred at about 5400' MSL. The Pueblo VOR is about 1-1/2 miles from the runway threshold, just off the runway centerline extended. This is poor radio aid geometry for the RNAV approach. The #1 DME signal was invalid at 5500'; the VOR signal was intermittent. At 500' above touchdown zone, the airplane was aligned with the left edge of the runway at 1-1/2 miles DTW. This is the lowest point to which the RNAV/RNAV approach will be guided. The autopilot was left engaged and the airplane converged back to the runway centerline just prior to the runway threshold. A go-around was made from the runway threshold.

The next approach was an RNAV/RNAV Flight Director approach to R/W 25R with a full stop landing. The pilot flew the approach down to 500' above touchdown zone. The airplane was about 1-1/2 miles out and about 100' off the runway centerline extended. A visual landing from that point was accomplished satisfactorily. The approach functioned properly and the pilot had no difficulty following the flight director commands both vertically and laterally throughout the approach.

At the end of this first series of approaches, the two-segment approach system was reviewed and the following conclusions made:

1. The lighting was adequate and suitable for daylight approaches.

2. The CDU display as acceptable as selected for the approaches and adequately indicated the approach being flown.

3. The 1000' AG and 500' AG points are adequate and sufficient for crew cross check of the approaches.

4. The auto-tune function can be monitored satisfactorily by using the Headset Audio and the CDU Radio Identification.

The next approach was an autocoupled RNAV/ILS to R/W 25R. The initial altitude was 9000' and the airspeed held at 250 KTS through the 90° turn-in and the initial capture. The airplane overshot the localizer on the turn-in and was in excess of 2 dots deviation as it reached runway heading. The upper transition occurred with the airspeed at 250 KTS. The throttles were retarded to idle and the airplane slowed to 200 KTS by the time 7800' MSL was reached. At this point, the deviation from localizer was too wide and the path required to align with the runway prior to the lower capture was unsafe and the system disengaged.

The cockpit indications of the two-segment approach disengagement were: The autopilot disengaged, illuminating the Master Warning Light and turning on the Warning Horn. (This is the DC-8-61 normal warning system for an autopilot disengagement.) The Flight Director fly bars were biased out of view. The HSI vertical and lateral deviations were both flagged. The distance to waypoint window was still illuminated and the CDU continued to pass waypoints. When the departure end of the runway was passed, the ANS-70A system reset itself since the next waypoint (ROSE 9) was programmed.

The approach was repeated (an RNAV/ILS Autocoupled Approach to R/W 25R). On

this approach, bearing/distance waypoints were entered in the flight plan to lengthen the path into the approach, and the proper airspeeds were maintained.

At upper segment AMBER, the autopilot disengaged and would not re-engage. The flight director was valid and the approach continued on flight director. The approach was normal, except that when the approach runway waypoint was passed, the departure runway waypoint also passed and the area navigation system was indicating enroute to ROSE 9. The autopilot would not re-engage and operate until the SMART box was replaced in the radio rack.

The next approach, an RNAV/RNAV Flight Director to R/W 25R, was flown, flying below the flight director commands. As the airplane passed the Pueblo VOR, the DME and VOR signals became intermittent. Soon thereafter, all radio valids were lost and the system continued on air data for only 15 seconds as designed. At this time, with the airplane 250' above touchdown zone, the system tripped off. A departure waypoint was entered in the flight plan and the system reset and indicated the departure route from Pueblo to Denver.

The flight plan to Denver, including an approach to R/W 26L was entered in the flight plan. While enroute, a power failure was simulated by pulling the circuit breakers to the ANS-70A system. Immediately the autopilot disengaged with its appropriate warnings, the flight director bars biased out of view, and the HSI deviations were both flagged. The FAULT light on the CDU illuminated, the CDU presentation (flight plan page) would not edit or change and the Distance to Waypoint (DTW) did not change. The flight director mode switch was moved to the F/I mode. Immediately the lateral guidance bar came into view and operated properly. The autopilot was engaged in TURN KNOB mode. Altitude Hold placed ON, and the Heading Select Mode selected. The autopilot followed the heading bug. Colorado Springs frequency was placed on the #1 VHF radio and when the auto-tune knob (HSI course knob) was pulled out, the radio immediately tuned to Colorado Springs (COS Identifier), and the DME window illuminated. This was accomplished in about 15 seconds, without any unusual motions of the airplane.

The power was left off for 2-1/2 minutes. Restoring power would not reset the system. It required a new IPL (Initial Program Load) to restore ANS-70A operation.

When the RNAV system was re-established, an autocoupled RNAV/ILS was made to R/W 26L at Denver. The reported winds were 110°/3 KTS. The descent into the approach was made with an along track offset and the base leg was offset 2 miles to the right. The two-segment system operated properly to this runway. The airplane position was to the right of the centerline slightly when the autopilot was disengaged at 150' above touchdown zone. The pilot was able to align the airplane with the runway for a normal landing.

FLIGHT NUMBER 2

The RNAV flight plan was pre-programmed to fly the LIMON 1 departure, DEN 1 - PUB Route. ROSE transition to R/W 7L at Pueblo.

The airport procedures at Stapleton require that the pilot fly a noise abatement departure profile. This profile is above the RNAV programmed altitude profile and the pitch steering therefore indicated a fly-down command for the initial climb. ATC required a left turn for departure, rather than the LIMON 1 departure. The waypoint TRACK (TRAK2) was entered and the other departure

deleted. The pilot then had a revised RNAV route that was easily followed. A left course offset was programmed to LIMON waypoint and it functioned properly.

While enroute from LIMON to HOVER, at 15,000' MSL on autopilot, a three (3) second power interruption was imposed upon the ANS-70A system. The system tripped again and required IPL and re-programming to reinstate the RNAV system. While flying inbound to ROSE 9 waypoint, autocoupled, the altimeter was abruptly changed from 29.96 to 29.93. There was a slight drop in the altimeter and a rise in the HSI vertical deviation. The autopilot made the adjustment smoothly.

The next event was to fail the K-104 relay in the RNAV switching unit. This occurred enroute to an RNAV/ILS approach. It made no apparent change in the approach system except the vertical deviation on the HSI was switched to basic glide slope rather than upper segment. The HSI vertical deviation bar immediately dropped to full scale down. The autopilot continued to fly the approach altitude. The auto-tune switch was pulled out and the aircraft reverted to standard navigation systems. The F/D bar biased out of view. The flight director mode switch was moved from RNAV to F/D and the flight director lateral guidance bar came into view, giving proper commands relative to the heading bug. The airplane was then flown on the flight director to a standard ILS approach. The approach was good.

The next approach was set up as an autocoupled RNAV/ILS to R/W 25R. While on the approach to upper (UPPER SEGMENT amber), K-104 relay was again failed. The vertical deviation bar switched to the basic glide slope. There was no apparent change to the approach. When the K-104 relay was restored, the autopilot disengaged, and it would not re-engage. The approach was continued on the flight director and K-205 relay was failed. There was no apparent change in the approach at this time. The upper capture occurred and the airplane was flown through the upper transition to the upper segment. The autopilot would not engage when attempted. The pilot was holding pitch forces on the wheel at this time. The autopilot was re-engaged when no forces were on the control wheel (7600' MSL, 5.8 distance to waypoint on upper segment). The flight director functioned normally.

The flight director mode switch was moved to VOR/LOC (in auto-tune, the bars should be out of view and the F/D flag in view). The flight director bars were in view and no flight director flag. The autopilot was disengaged and the flight director was turned off. The raw data presentation was indicating properly. Passing the approach end of the runway, the RNAV steering returned. It was noted that the departure runway waypoint had also been passed but the actual location of that waypoint was a mile straight ahead. The pilot flew the airplane using raw data to ROSE 9 waypoint.

The next approach, an autocoupled RNAV/ILS was made to check the effect of CADC failure after UPPER SEGMENT green. As the turn-in to R/W 7L was made, the CADC circuit breaker was pulled and the system disengaged. The approach was re-entered and stabilized on the upper segment, with UPPER as the "TO WAYPOINT" and a 90° turn to make the system disengaged. In this case, the UPPER waypoint can be passed prematurely and the turn-in is difficult for the system to make. An enroute waypoint was programmed ahead of UPPER and the system performance was good. When the CADC circuit breaker was pulled, the system tripped. The "System Status" page indicated failure of the air data computer and the indicated airspeed input, which the system gets from the CADC.

On the next approach, autocoupled RNAV/ILS to R/W 7L, the effect of a #1 localizer receiver failure was checked. The airplane was stabilized on the upper segment and the #1 localizer receiver failed. The system tripped off and the "System Status" page said FAULT LOCALIZER.

On the next approach, an autocoupled RNAV/ILS to R/W 7L, the effect of a #1 VHF receiver failure was checked. An enroute waypoint one mile from UPPER was observed to provide the minimum acceptable system performance on a 90° turn-in to final approach course. The airplane was stabilized on the upper segment and the #1 VHF receiver circuit breaker pulled. Fifteen seconds later, the system was tripped off.

On the next approach, an autocoupled RNAV/ILS to R/W 7L, the effect of DME failures was checked. The airplane was stabilized on the upper segment and the #3 DME circuit breaker pulled. This had no affect on the system. The "System Status" indicated the #2 DME fault (the RNAV system refers to the aircraft's #3 DME as the RNAV's #2 DME). The #1 DME receiver circuit breaker was pulled. The system tripped in about 20 seconds.

The next two approaches were flown to check the effects of hardover failures of the autopilot. The autopilot ACO (Automatic Cut Off) was deactivated for these tests.

An autocoupled RNAV/ILS, was initiated at 180,000 lbs gross weight and 27.4% MAC. At LOWER SEGMENT green, 5450' MSL (about 650' above touchdown zone) the failure was induced. (Hardover signal nose-up) The airplane started a pitch up, and was easily over-powered as the airplane leveled off.

An autocoupled RNAV/ILS was initiated at 178,000 lbs. gross weight, 27.4% MAC and Vref 126 knots. At LOWER SEGMENT green, 5380' MSL, the failure was induced (hardover signal nose down). The airplane started a pitch down while descending on the upper segment 1/2 dot above the glide slope. Six seconds after the induced failure, the autopilot was disengaged at which time the airplane was at 5270' MSL, on the G/S centerline, with a rate-of-descent of 1450 feet per minute. Five seconds later, with the pilot well into recovery, the rate-of-descent was 600 feet per minute. The altitude was 5220' MSL and the airplane was about 1/8 dot below the glide slope. In the next five seconds, the airplane flew above the glide slope by one dot, had descended to 5210' and was essentially recovered. The hardover failures presented no problem to the two-segment approach.

The next approach was an autocoupled standard ILS. The autopilot was disengaged at 100' above touchdown zone and a departure to Denver was initiated. The standard approach was normal in every respect and did not show any sign of interference. The ANS-70A system was on during this approach but the airplane was not in auto-tune.

Enroute to Denver with the airplane on autopilot, auto-tune and AUX-NAV, a 1-1/2 second power interrupt was imposed upon the ANS-70A system. The interruption caused the autopilot to disengage, and the flight director to bias out-of-view with the appropriate flags. The CDU was frozen and its FAULT light was on. Resetting the power did not restore the ANS-70A system and it required IPL function and re-programming to function again.

The system was programmed for an RNAV/ILS to R/W 35 Denver. The approach was entered and the approach progress display, autopilot, and flight director functioned properly. The glide slope on the runway 35 ILS was inoperative and when the airplane reached UPPER SEGMENT amber the system tripped off. The approach was deleted and an RNAV/RNAV appraochjentered but the airplane reached the point of UPPER SEGMENT green before the system was fully restored and the autopilot and the flight director would not engage. The pilot followed the upper segment raw data down to 1000' above touchdown zone and then made a visual transition and landing to the runway.

FLIGHT NUMBER 3

After takeoff the departure route proceeded from Denver to HOVER waypoint, flying RNAV enroute completely.

The next approach flown was an RNAV/ILS using the raw data only. The flight director and autopilot were left off while the airplane was in auto-tune. The pilot followed the raw data deviations and navigated to align the airplane on the final approach course outside UPPER. The upper transition was made successfully and while stabilized on the upper segment the flight director was moved to RNAV. The command bars did not come in view but the flight director flag did. The flight director was turned OFF and an attempt was made to engage the autopilot in AUX-NAV. It would not engage. At no time in either of these attempts did any APD light illuminate or was there any guidance provided. The pilot then followed the raw data through the lower transition and onto a low approach.

The next approach was an autocoupled RNAV/ILS to R/W 7L. On this approach the ADF functions were monitored while the air conditioning recirc fans were cycled. There was no noticeable effect on the ADF system or on the RNAV system with the electrical surging caused by the recirc fans. The approach was continued down to 100 feet where the autopilot was disengaged. The pilot followed the lateral guidance while starting a go-around. The airplane passed the approach runway point and the vertical guidance on the flight director biased up out of view and the GO AROUND light illuminated green. The pilot continued to follow the lateral guidance and when the departure runway waypoint passed the GO-AROUND light went out, the vertical guidance returned and the ANS-70A system provided enroute guidance to the next waypoint.

The next approach was an autocoupled RNAV/ILS to check the effects of failures of the switching unit relays (K-102, K-104 and K-106). When flying towards the approach with RNAV APPROACH green on the autopilot, the K-102 relay was failed. The airplane started to descend and no longer followed the vertical guidance as provided by the RNAV system. It was immediately recognized and the pilot followed the flight director vertical command and returned the airplane to the proper altitude.

The pilot followed the flight director's commands and continued on. After UPPER SEGMENT amber relay K-104 was failed. With this failure, the vertical deviation indicator on the HSI switched to the glide slope and was reading the same as the ADI glide slope indicator and the co-pilot's glide slope indicator. The rest of the system appeared normal. After LOWER SEGMENT amber relay K-106 was failed, the DME window on the captain's HSI was illuminated with dashes. The ANS-70A system could not tune the radios and after 15 seconds the system tripped, with the flight director flag in the ADI. The "System Status" page of the CDU indicated failure of #1 VOR.

The next approach, an autocoupled RNAV/ILS to R/W7L, was to check the effects of failure of relay K-109. The approach appeared to be normal except at LOWER SEGMENT amber, when the localizer deviation was about 1/3 dot right off course and the deviation was not reduced to 0 but instead gradually increased so that at 2.6 distance to waypoint (DTW) and 5800' MSL, the airplane was 1/2 dot right off course. The system started a correction and was back on centerline at 2.1 DTW and 5500' MSL but with a heading of 070° which was 5° left of course. At 1.6 DTW and 5200' MSL the airplane was 1/3 dot left of course and the heading 075°. The airplane continued to make some oscillations on the localizer -- at 0.7 DTW and 4900' MSL the airplane was 1/2 dot right of course. Here the autopilot was disengaged. The only indication of this failure is the lack of close tracking of the localizer. The oscillations did not exceed 1/2 dot and there were five overshoots.

The next approach, an autocoupled RNAV/ILS to runway 7L, was to check the effect of a misset baro correction (high) on the Captain's altimeter. The proper baro setting was 29.87 (this was set on the co-pilot's altimeter and the altimeter read 8000' MSL). The Captain's altimeter was set at 30.87 and read 9000' MSL. The approach was continued with the airplane flying 1000' below the correct intercept altitude. At 6.3 DTW, 8000' MSL on Captain's altimeter (7000' MSL actual) the airplane crossed the outer marker the HSI deviation indicated on the upper segment, the ADI glide slope deviation indicated 1-1/2 dots above the glide slope. At 5.5 DTW, 7000' on the Captain's altimeter the HSI indicator on the upper segment and the ADI indicated 1/2 dot above the glide slope. At 4.9 DTW, 7100' on the Captain's altimeter, on the upper segment the airplane passed below the basic glide slope as indicated on the ADI and the system tripped, with the appropriate warnings.

The next approach, an autocoupled RNAV/ILS to runway 7L, was to check the effect of a misset baro correction (low) on the Captain's altimeter. The correct altimeter setting was 29.87 and this was set on the co-pilot's altimeter: 28.87 was set on the Captain's altimeter. The airplane was flown at 10,000' MSL -- the Captain's altimeter read 9000'. At 6.3 DTW and 8000' indicated on the Captain's altimeter (9000' MSL actual) the airplane crossed the outer marker. The HSI indicated on the upper segment and the glide slope full scale below the airplane. At 4.9 DTW (LOWER SEGMENT amber) the upper segment was still indicated on and the glide slope still full scale below the airplane. (Captain's altimeter 7100', co-pilot's altimeter 8100'.) At 1.6 DTW, 5200' indicated on the Captain's altimeter (6220' MSL on the co-pilot's altimeter), the HSI indicated on the upper segment and the ADI indicated glide slope still full scale below the airplane. The system tripped at this point.

The next approach, a flight director RNAV/ILS to runway 7L, was flown with a deliberate overshoot of the upper segment. The approach was flown such that at 5.0 DTW, 6900' MSL the HSI was indicating the upper segment was just 2 dots below the airplane. At 1.7 DTW the airplane reached 500' above touchdown zone and the systems tripped.

The next approach, a flight director RNAV/ILS to runway 7L, was flown with a deliberate undershoot of the upper segment. The airplane was flown 2 dots below the upper segment and at 4.9 DTW the LOWER SEGMENT light turned amber and then immediately green indicating capture of the glide slope. The flight director commands provided proper guidance to and tracking of the glide slope. The rate of descent was about 1700 feet per minute and the airplane went below the glide slope on this transition by one (1) dot. The airplane was still 4.4 DTW and 1300' above the touchdown zone. By 3.9 DTW and 1200' above the touchdown zone the airplane was back on the glide slope.

The next approach, a flight director RNAV/ILS to runway 7L, was flown deliberately 2 dots left of the localizer while on the upper segment. At 5.6 DTW, 7600' MSL the airplane was on the upper segment and 1 dot left of localizer centerline. At 4.9 DTW, 7160' MSL the airplane reached 2 dots left of localizer and tripped. The pilot pulled out the auto-tune switch and reverted to the standard ILS system. He placed the flight director mode selector to APPROACH and flew the commands. By 600' above touchdown zone the airplane was back on the localizer and glide slope.

The next approach, an autocoupled RNAV/ILS to runway 25R, was to check the engine out effects. The approach was started at 210,000 lbs. gross weight with Vref 136 kts. The approach was flown normally down to 7000' MSL where the #4 engine was retarded to idle simulating an engine out. The other three engines were advanced in power to compensate for #4 and no rudder trim was applied. The approach continued through the lower transitions to 200' without difficulty where the autopilot was disengaged, and a landing accomplished.

The following items were checked and found to function properly or as indicated. Those things were required by the Inspection Authorization prior to receiving the STC for line operation.

1. During IPL, the tape number P/N 10838912 was indicated on the CDU. When the CDU was programmed with a waypoint, that waypoint information coincided with the actual waypoint data in bearing distance from the defining radio and the latitude and longitude.

2. Flight plan can be edited -- on the ground, enroute, during a STAR, after an approach, but <u>not</u> during an approach from UPPER to the departure end of the runway.

3. The system provides no capability to alter two-segment approach geometry. Attempts to edit pre-stored altitudes associated with two-segment approach waypoints result in an ERROR message on the CDU. Deletion of any one waypoint in the two-segment approach results in deletion of the entire approach from the flight plan.

4. The standard system #1 flight director (Captain's), #1 radios and compass functioned normally on takeoff and departure.

5. The F/I mode on the Captain's flight director functioned normally with or without auto tune.

6. Standard ILS #1 System.

7. Standard ILS Flight Director.

8. Standard ILS, #1 system autocoupled.

9. The audio levers were used for pilot verification of the system: #1 VHF for #1 VHF, #1 HF for the ILS receiver, #2 HF for the #3 DME.

10. Enroute to RNAV/ILS auto-coupled.

11. RNAV/ILS auto-coupled approach.

12. RNAV/ILS auto-coupled with 20 KTS tailwind.

13. RNAV/ILS 18 KT headwind.

14. RNAV/ILS autocoupled transitions.

15. RNAV/ILS Flight Director.

16. RNAV/ILS transitions, flight director.

17. RNAV/ILS flight director approach, crew cross-coordination adequate.

18. RNAV/ILS approach through the Go-Around mode to the approach end of the runway.

19. RNAV/ILS go-around by selecting GO-AROUND button.

20. Cockpit capability to properly indicate airplane position on RNAV/ILS approach.

21. RNAV/ILS and RNAV/RNAV with maximum landing weight and maximum forward CG for that landing weight, and light landing weight with aft C.G.

22. Enroute to RNAV/RNAV Autocoupled.

23. RNAV/RNAV Autocoupled Approach.

24. RNAV/RNAV witn 15 KT headwind.

25. RNAV/RNAV Autocoupled Transitions.

26. Enroute to RNAV/RNAV Flight Director.

27. RNAV/RNAV Flight Director.

28. RNAV/RNAV Flight Director Transitions.

29. RNAV/RNAV Go-Around at Approach End of Runway.

30. RNAV/RNAV Approach with intermittent Radio Signals.

31. RNAV/RNAV Approaches mode annunciation.

32. Cockpit Capability RNAV/RNAV.

33. RNAV departure and enroute normal cross checked from Co-Pilot's instruments.

34. Enroute and approach lighting adequate for day conditions.

35. Heading Select inoperative with flight director in RNAV.

36. Only one means of misplacing the upper segment (misset baro-correction) could be accomplished. Attempts to mis-adjust a DME interrogator in the shop revealed that total adjustment was limited to about $\pm$ .2 N.M., not enough to appreciably displace the upper segment.

37. Baro-correction misset high and low.

38. Two-dot overshoot of the upper segment during transition.

39. Two-dot overshoot while on upper segment.

40. Two-dot envelope on upper segment.

41. Two-dot envelope on U/S 500 feet above touchdown zone and not captured.

42. Power interrupt 2-1/2 minutes.

43. Three second power interrupt.

44. One and 1/2 second power interrupt.

45. Ten seconds below the glide slope when indicated on U/S. 1.6 DTW reached and glide slope not captured.

46. Warning of system disengagement.

47. RNAV/RNAV lower segment radios invalid.

48. K-104 relay failure enroute.

49. K-205 relay failure flight director - K-104 failure.

50. Relay failures: K-102, K-104, K-106, K-109.

51. #1 CADC failure.

52. #1 localizer failure.

53. #1 VHF NAV failure, #3 DME failure, #1 DME failure.

54. Hardover failures (nose-up and nose-down) with aft C.G. light gross weight.

55. RNAV/ILS autocoupled glide slope failure.

56. Raw data approach. A/P and F/D cannot be engaged after passing UPPER SEGMENT green.

57. ADF function normal - RNAV ILS normal with electrical surge caused by recirc fans.

58. CDU programmed in flight.

59. Additional runways and airport to which two-segment approaches are flown.

60. Reversion to standard ILS after a system trip at 1000'. Engines out while autocoupled on upper segment.

APPENDIX D

Pre-Service Approach Check Flights

D-1 through D-5	Log of Approaches
D-6	Summary of Results by Runway
D-7 through D-9	Seattle Visual Bay Approach Description

DC-8 TWO-SEGMENT APPROACH ROUTE QUALIFICATION

SEATTLE - SEA-TAC AIRPORT

DATE	APP.#	MODE/TYPE/RUNWAY	REMARKS
4/24/74	1	F/D RN/ILS - 16R	Some jitter in the F/D pitch bar. Autothrottle deactivated. Autotune light operational - it will not dim. End of the runway waypoint changed to touchdown spot. Good approach.
	2	F/D RN/ILS - 16R	Aborted - used the "DIRECT TO". The LAT/LONG turning point did not pass. Second "DIRECT TO" dropped the two-segment valids. APD lights went out.
	3	F/D RN/ILS - 16R	Good approach. Lateral steering excellent. Pitch appeared sensitive.
	4	F/D RN/ILS - 34L	High speed entry - 180 KTS on entry - 195 KTS to outer marker. F/D commanded 12° nose down. Followed the upper segment well.
	5	A/C RN/RN - 34L	Aborted - came out of heading command too late. The LAT/LONG turning point was inside upper. Gave the airplane two 180° turns which it wouldn't accept. System tripped.
	6	A/C RN/RN - 16R	Good approach. Lower transition occurred then the autopilot disengaged and the F/D pitch bar biased out-of-view. At 500' AG, the airplane was 1-3/4 dot right of the localizer centerline and 1/8 dot above the glideslope.
	7	F/D RN/RN - 16R	STC verfication - 3/4 dot left of localizer centerline at 500' AG, essentially on glideslope.
	8	F/D RN/ILS - 34L	High speed entry accelerated to 225 KTS (ground speed on CDU) - F/D followed ok. Good approach.
	9	A/C RN/RN - 16R	Good approach. 1/4 dot left of LOC at 500' AG. The autotune light is too dim when the sun shines on it.
	10	A/C RN/ILS - 16R	Used the Elliott Bay noise abatement STAR for a lead in to the approach. The two-segment valid dropped (APD lights went out) each time one of the lead-in STAR waypoints were passed. Re-entered the approach each time it dropped, except the last where the system was reverted to standard. From 8 miles out we were able to get down on the glideslope by the outer marker and make a standard ILS. Reversionary procedure works fast and well.

	APP.#	MODE/TYPE/RUNWAY	REMARKS
	11	A/C RN/RN - 34L	DME dot right of localizer at 500' AG. Good position to complete a visual approach.
	12	A/C RN/RN - 16R	Used the Elliott Bay noise abatement lead-in STAR again. The two-segment valids dropped out when Puget Waypoint passed. Deleted STAR and entered each waypoint in the lead-in separately. The airplane continued past each waypoint and completed the approach successfully - 1/3 dot left at 500'AG. Good approach.
	13	F/D RN/ILS - 16R	Did a "DIRECT TO" Germo waypoint from the south - while heading straight at the waypoint. Passed Germo, Elit2 and completed the approach nicely.
	VANCOUVER - INTERNATIONAL AIRPORT		
4/25/74	14	F/D RN/ILS - 8	Aborted - reverted to standard. Edited the inbound course to the final approach waypoint by 90° and that waypoint and upper passed. System tripped. Landed - tried a "DIRECT TO" while on the ground - got a CDU lock-up. Made IPL and started over.
	15	F/D RN/ILS - 8	Flew closed path waypoint to waypoint. Good approach.
	16	A/C RN/ILS - 8	ADMOR waypoint is not lined up with upper exactly, 10° course change. Good approach.
	17	A/C RN/RN - 8	Good approach - 1 dot right of runway centerline at 500' AG, about on glideslope.
	18	A/C RN/RN - 26	Good approach. 3/4 dot left of centerline and 1/2 dot above G/S at 500' AG. Following this approach, we got into a holding situation at a waypoint - this was required because of traffic. Establishing the holding pattern, using the RNAV system, was a major effort beyond what a line pilot would be expected to do.
	19	F/D RN/ILS - 26	Used BLI instead of YVR as the primary VOR. Acceptable approach.
	SEATTLE - SEA-TAC AIRPORT		
	20	F/D RN/ILS - 16	Vectored from Vancouver. Runway changed while 15 minutes out. Did a flight plan change - flew into Puget waypoint, King 4, Germo, Elit 2, (the Elliott Bay path for noise abatement). Made an excellent approach.

CHICAGO - O'HARE INTERNATIONAL AIRPORT

DATE	APP.#	MODE/TYPE/RUNWAY	REMARKS
4/25/74	21	F/D RN/ILS - 14R	Vectored straight in to 14R. We requested 165 KTS to outer marker - ATC wanted 200 KTS. Our slow speed backed up the traffic behind us. Approach was ok.
4/26/74	22	F/D RN/RN - 22R	Abort - system got tangled in vertical events. Put to close turn-in and late "DIRECT TO".
	23	A/C RN/RN - 22R	Flew waypoint to waypoint prior to upper. Good approach. Approximate 300' right of runway centerline at 500' AG.
	24	F/D RN/RN - 22R	12 KT tailwind. Good approach.
	25	A/C RN/ILS - 14L	Abort - waypoint passed prematurely. A/C and F/D commands were not where they should be. System tripped - would not start down.
	26	A/C RN/ILS - 14L	Abort - glideslope transmitter went off the air.
	27	A/C RN/ILS - 14R	Ok.
	28	F/D RN/ILS - 14R	Abort - too close - on turn-in.
	29	A/C RN/RN - 14R	Ok - 2 dots right of LOC centerline at 500'. One dot below glideslope.
	30	F/D RN/RN - 14R	Ok. Flew right and low of localizer and glideslope - looked the same as approach 29.
	31	F/D RN/ILS - 14L	Good approach. Long vector to initial.
	32	A/C RN/ILS - 27R	Abort - guidance on initial appeared in error. system tripped. Re-entered and it did the same thing.
	33	A/C RN/ILS - 27R	Used a long vector to initial (15 min). Auto-tune light too bright at night. Just past upper, the airplane started oscillating back and forth across the localizer. Autopilot disengaged. The flight director held a 1/2 dot stand-off above the upper segment. Entire system tripped at 700' AG . Reverted to standard.
	34	A/C RN/ILS - 27R	Abort - wouldn't fly approach.
	35	A/C RN/ILS - 27R	Flew 3/4 dot right of LOC right on upper segment. Started oscillating - tripped at 500' AG.

Cont. (ORD)

DATE	APP.#	MODE/TYPE/RUNWAY	REMARKS
	36	A/C RN/ILS - 32L	Good approach - 1/4 right of LOC centerline at upper.
	37	A/C RN/ILS - 32R	No approach - wrong flight plan entry. Had waypoints in wrong order.
	38	A/C RN/ILS - 32R	Small oscillation approaching upper. Good approach past upper, down to 100' AG on A/P
	39	F/D RN/RN - 14R	Abort - Too close on vector.
	40	F/D RN/RN - 14R	Ok - 2 dots right of localizer.
	NEWARK - INTERNATIONAL AIRPORT		
4/26/74	41	A/C RN/ILS - 4R	Edited inbound course to the initial approach waypoint - that waypoint and upper passed prematurely. G/S flag was in view until 3 miles from KILMER. At upper capture, system aborted the course at each waypoint. Upper, lower, touchdown and runway shifted 180° - Reverted to standard and landed ok.
4/27/74	42	A/C RN/ILS - 22L	Abort - vectored in too close.
	43	A/C RN/ILS - 22L	Aborted - too close to upper.
	44	A/C RN/ILS - 22L	Longer initial - made some oscillations following "DIRECT TO" prior to upper. Captured and flew upper segment ok. Went 1/4 dot below G/S on lower transition - 1 dot high at 200' AG. Also noticed the DTW skipping numbers inside 1.2 DTW - similar to what was seen at SCK and RNO in March.
	45	A/C RN/RN - 22L	Good approach - 1/2 dot right of LOC at 500' AG.
	46	F/D RN/ILS - 22L	Vertical ok. Some lateral overshoot on turn-in - noticed the DTW skipping again 1.4-1.3-1.4-1.2.
	47	A/C RN/ILS - 4R	Abort - vertical events out of sequence.
	48	A/C RN/ILS - 4R	Abort - followed flight plan to upper capture then aborted.
	49	A/C RN/ILS - 4R	Lateral oscillation until passing MENLO waypoint. Approach ok after upper.

Cont. (EWR)

DATE	APP.#	MODE/TYPE/RUNWAY	REMARKS
	50	A/C RN/ILS - 4R	Upper segment displaced in - crossed outer marker at 2430' then shallowed out. Disengaged system at 500' AG.
	51	A/C RN/ILS - 4R	Full scale right of localizer - could fly back to runway if started by 800'AG. At 500' AG still possible but would require level-off first - not acceptable.
	52	A/C RN/ILS - 22L	Abort - Passed TETER too soon. Aborted at upper capture.
	53	A/C RN/ILS - 22L	Used 12 mile BD waypoint - approach ok.
	54	A/C RN/ILS - 4R	Used 10 mile BD waypoint. Some oscillations while headed into MENLO - aborted at 500' while on lower segment amber state.

SUMMARY OF THE ROUTE QUALIFICATION FLIGHTS

Approaches

Seattle

16R - RN/ILS	Good Approach.
16R - RN/RN	Acceptable approach - usually positions the airplane to the right of the runway centerline.
34L - RN/ILS	Good Approach.
34L - RN/RN	Good approach - airplane just slightly right of the runway centerline at minimums.

Vancouver

8 - RN/ILS	Good Approach.
8 - RN/RN	Acceptable approach - ADHOR waypoint is not on the localizer centerline. Airplane position is usually right of runway centerline.
26 - RN/ILS	Acceptable approach - the data base and VOR location causes some jogging in the flight path up until UPPER is the next waypoint.
26 - RN/RN	Good approach - airplane position is usually left of runway centerline and in closer to the runway at 500'AG than the 500'AG point on the ILS glideslope.

Chicago - O'Hare

14R - RN/ILS	Good Approach.
14R - RN/RN	Acceptable approach - airplane position is usually two dots right and one dot below ILS at 500'AG.
14L - RN/ILS	Good Approach.
22R - RN/RN	Acceptable approach - usually 300' right of runway centerline at 500'AG.
27R - RN/ILS	Unacceptable approach - there are data base errors that must be corrected.
32L - RN/ILS	Acceptable approach - seems to be some shifting in lower and touchdown waypoints.
32R - RN/ILS	Acceptable approach - errors appear very similar to 32L.

Newark

4R - RN/ILS	Unacceptable approach - data base and VOR geometry that cannot be handled with our current procedures.
4R - RN/RN	Unacceptable approach - data base errors too large.
22L - RN/ILS	Acceptable approach - data base errors in the initial approach waypoint.
22L - RN/RN	Good approach - 1/2 dot right of runway centerline at minimums.

RNAV Applicability to the Seattle Visual Bay Approach

On July 19, 1973, the FAA instituted a "Visual Bay Approach" to serve the Seattle-Tacoma Airport on Runway 16. This approach is to be used whenever the weather conditions are 3000-4 or better. The procedure is established to keep airplanes away from noise sensitive areas in the vacinity of Puget Sound.

An RNAV STAR was programmed to superimpose upon this visual procedure, the first waypoint being 18 miles north of the airport on the ILS localizer centerline; the second and third waypoints southwest along the desired flight path. This STAR then connected with the programmed two-segment approach to 16R at SEA-TAC Airport.

The initial altitude of the approach was raised to 4000'MSL which is 1000' higher than the Visual Approach. The results of this procedure were outstanding. The programmed path was flown more closely than the approach controller could vector the other traffic. The lead-in to a two-segment approach was excellent. The accuracy and repeatability were such that the procedure could have been operated to the two-segment approach minimums.

It can be concluded that the area navigation systems can fly curved paths successfully around noise sensitive areas and fly two-segment approaches following that path to provide community noise relief.

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

Seattle-Tacoma Tower
Room 401 - Admin. Bldg.
Seattle-Tacoma Airport
Seattle, Washington 98158

LETTER TO AIRMEN

On July 19, 1973, a new arrival procedure for turbo-jet and 4 engine turbo-prop aircraft landing at the Seattle-Tacoma Airport will be initiated. Although not an IFR approach, the procedure will be published in forthcoming instrument approach procedures publications. A preliminary copy of the approach is enclosed.

Titled "VISUAL BAY APPROACH", the procedure will serve runways 16 and is designed to furnish pilots of high performance aircraft a visual approach which provides noise relief to the community.

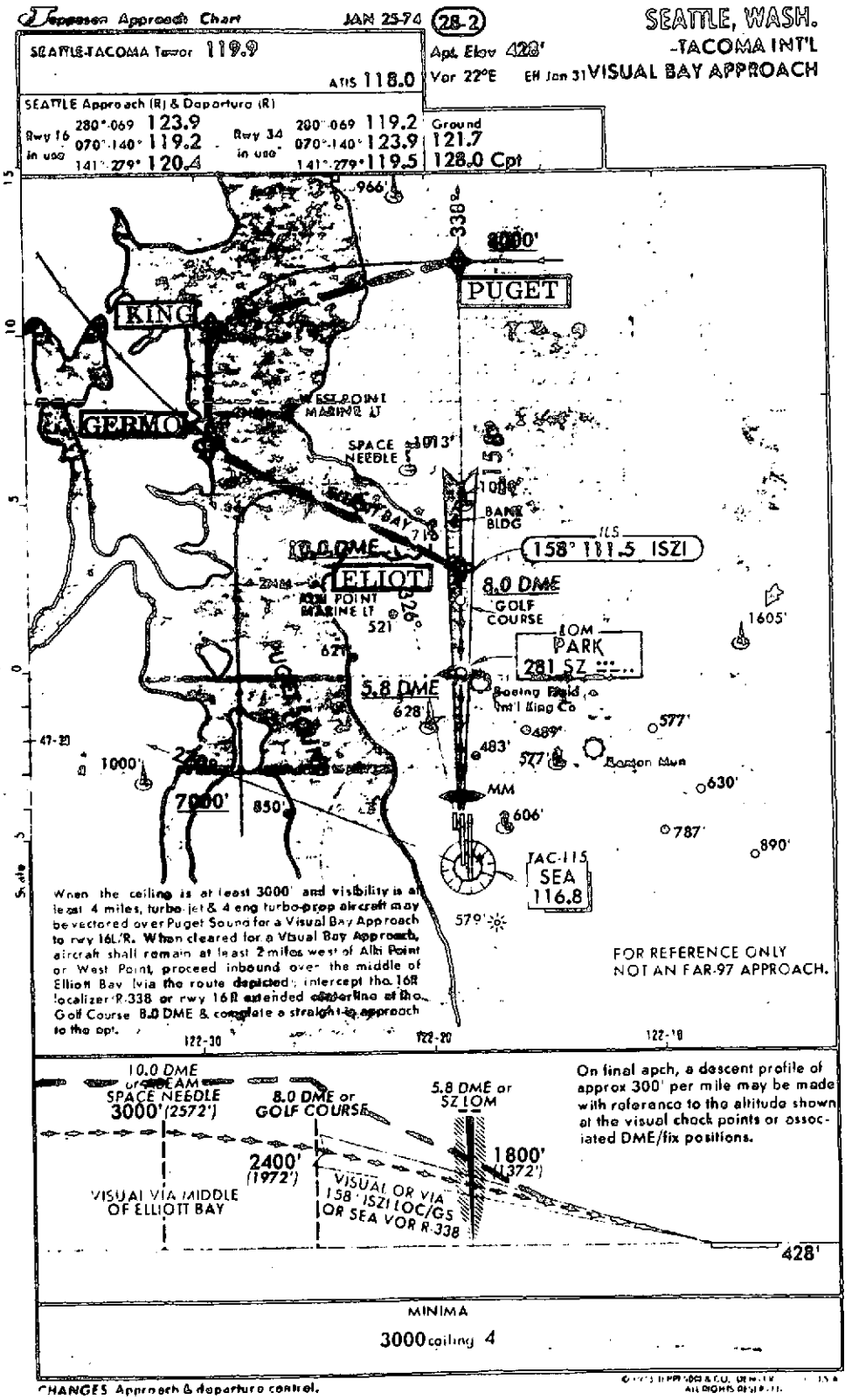
When runways 16 are in use, and the ceiling is at least 3000 feet with visibility at least 4 miles, the ATIS broadcast will include the announcement that the VISUAL BAY APPROACH is in use. Clearance for the VISUAL BAY APPROACH will be predicated upon the pilot's report that Elliott Bay and/or described traffic to be followed is sighted.

Residents on the north and south side of Elliott Bay are quite sensitive to aircraft overflying these land areas. When cleared for the VISUAL BAY APPROACH, we earnestly solicit your cooperation in following the route depicted <u>through</u> the Bay; and observing the minimum altitudes prescribed, so the objectives of the procedure may be realized.

Stanley D. Anderson

STANLEY D. ANDERSON
Chief, Seattle-Tacoma Tower

RNAV ELLIOTT BAY AND TWO-SEGMENT APPROACH PROCEDURE (DASHED LINES) SUPERIMPOSED ON VISUAL BAY APPROACH PROCEDURE

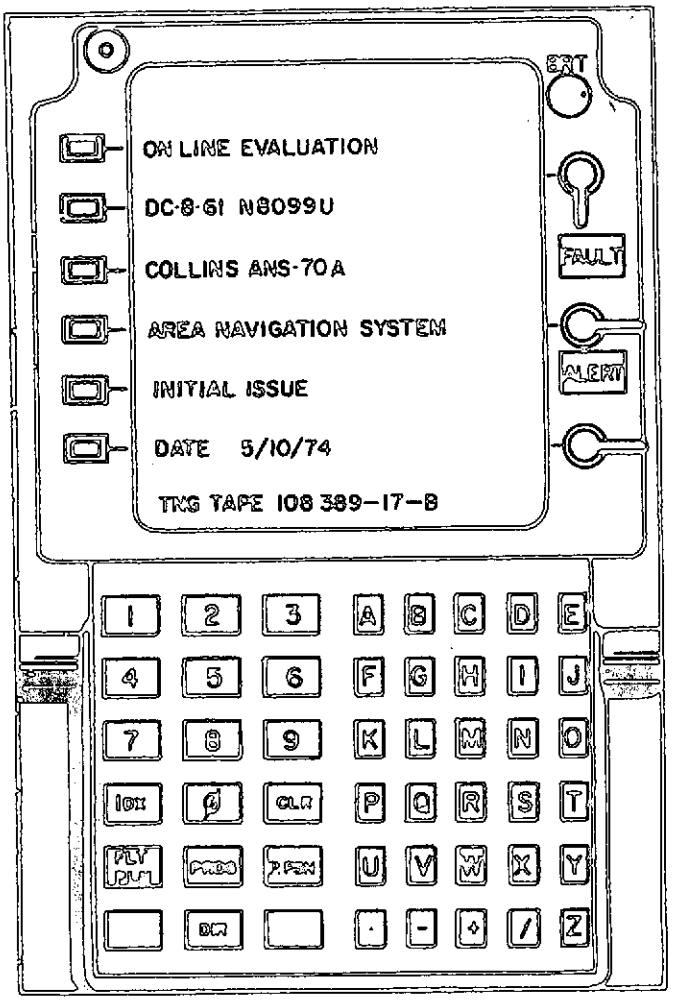


APPENDIX E

RNAV/TWO-SEGMENT APPROACH PILOT'S OPERATING GUIDE

Providing CDU operational instructions for the Collins ANS-70A system to be used in the In-Service Evaluation.

United Air Lines



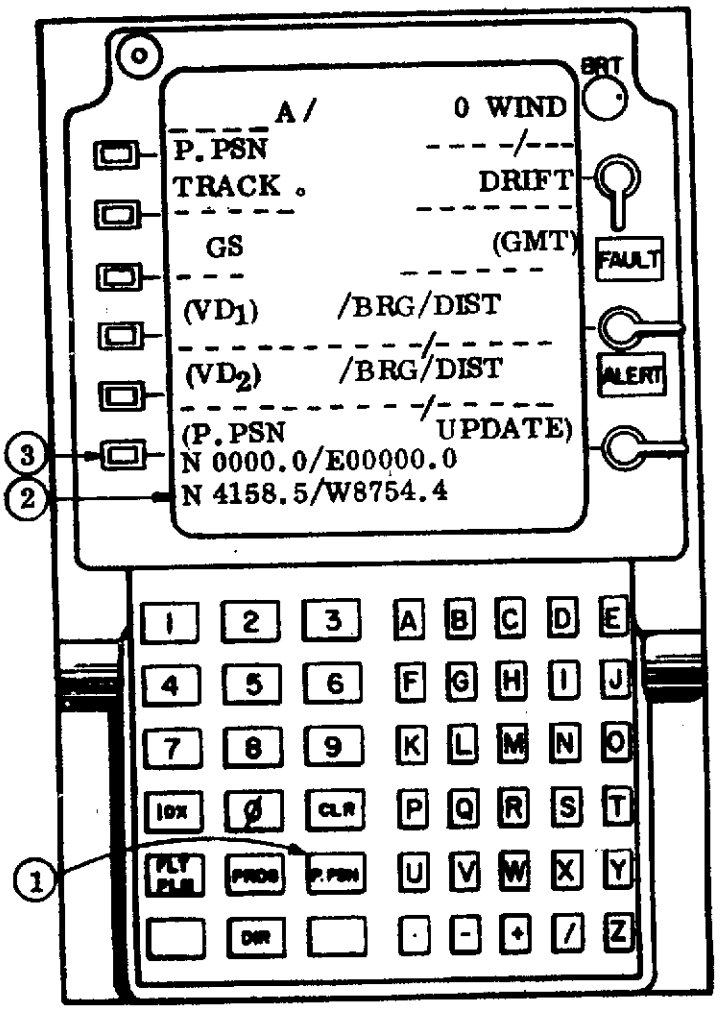
TWO-SEGMENT APPROACH

PILOT'S OPERATING GUIDE

INITIAL RNAV SET UP AT ORIGIN

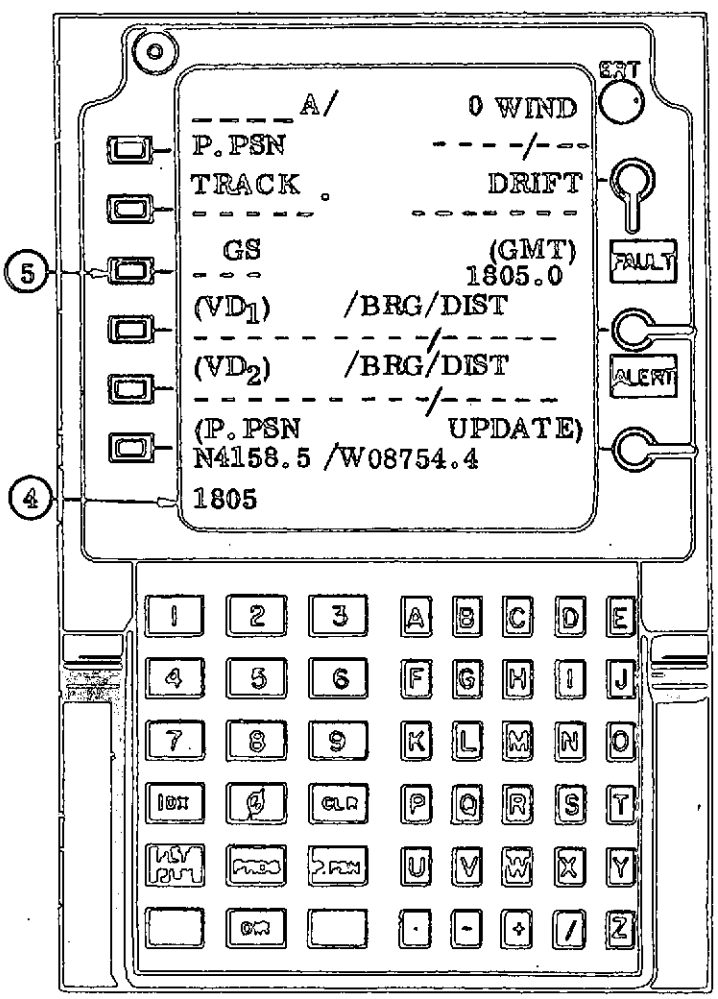
To prepare the RNAV system for operation, accomplish the following:

1. Press the P.PSN (Present Position) key on the CDU.
2. Using the Alpha Numeric Keyboard, type the station (Ramp) coordinates on the CDU scratch pad. This information is found on pages 414.3 and 414.4 of the Flight Operations Manual, and for selected airports in Attachment #1. (ORD shown in example)
3. Press the LINE KEY adjacent to (P.PSN UPDATE) to transfer coordinates from the scratch pad to the data line.



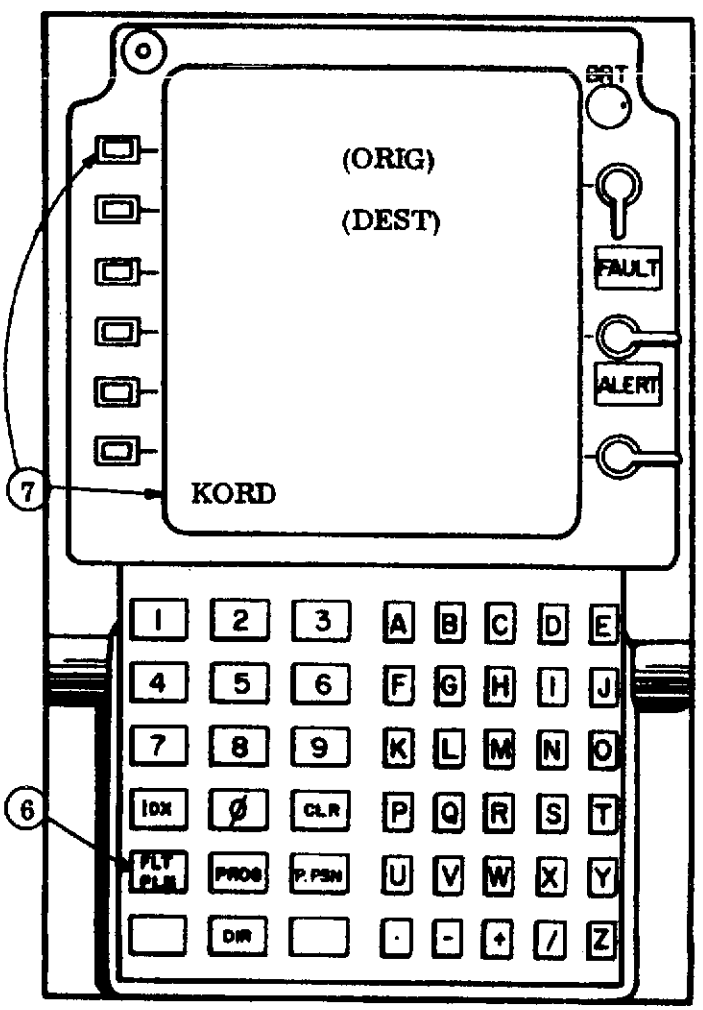
4. Type the current GMT time on the scratch pad.

5. Press the LINE KEY adjacent to the GS & (GMT) line to enter the time into the computer.

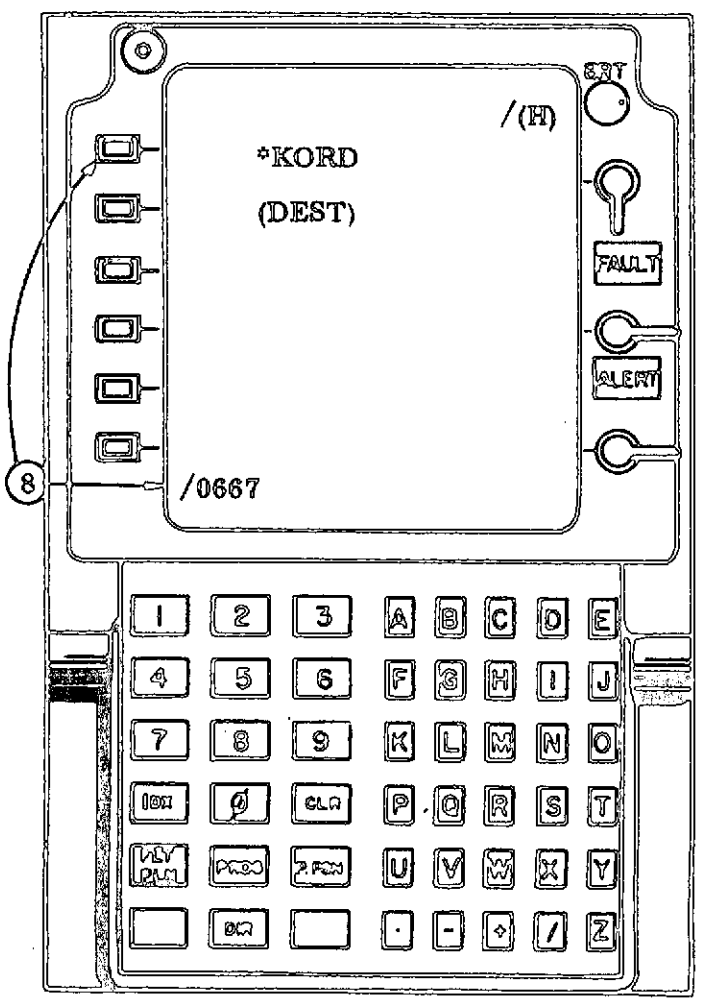


6. Press the Flight Plan Key [FLT PLN], (ORIG) & (DEST) will appear on the CDU.

7. Enter the origin airport by typing the airport designation on the scratch pad (i.e., KORD) and then press the LINE KEY adjacent to (ORIG).

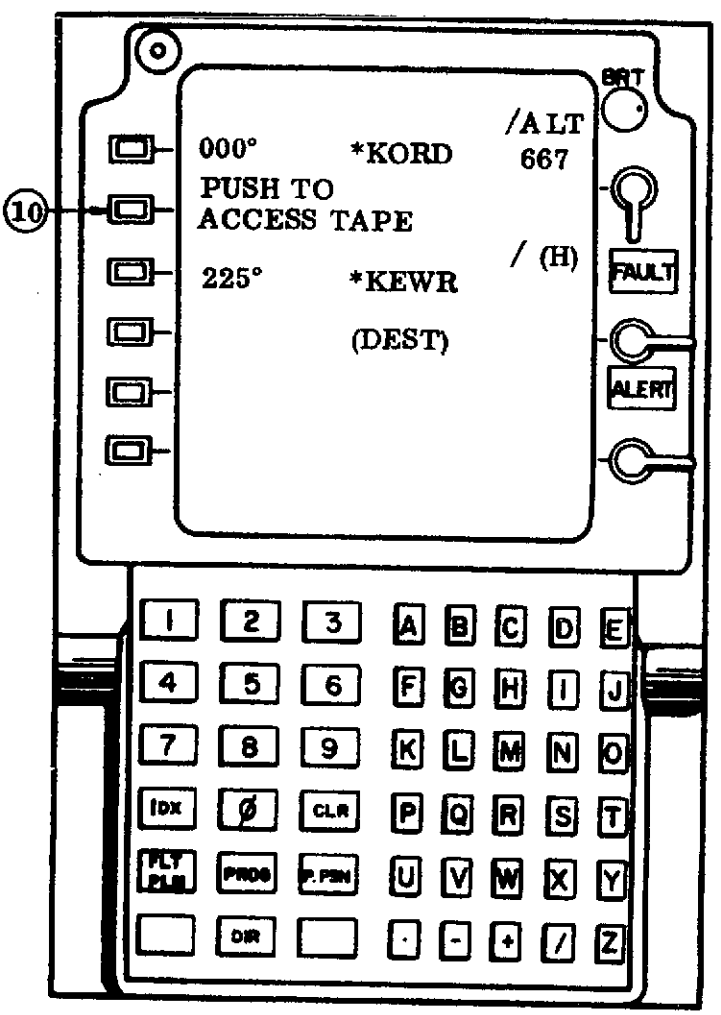


8. Enter the origin airport field elevation by typing the elevation on the scratch pad (i.e., /0667) and then press the LINE KEY adjacent to KORD on the CDU.
Note: Always place / ahead of altitudes.



9. Enter the destination airport by typing the airport designation on the scratch pad (i.e., KEWR) and then press the LINE KEY adjacent to (DEST).

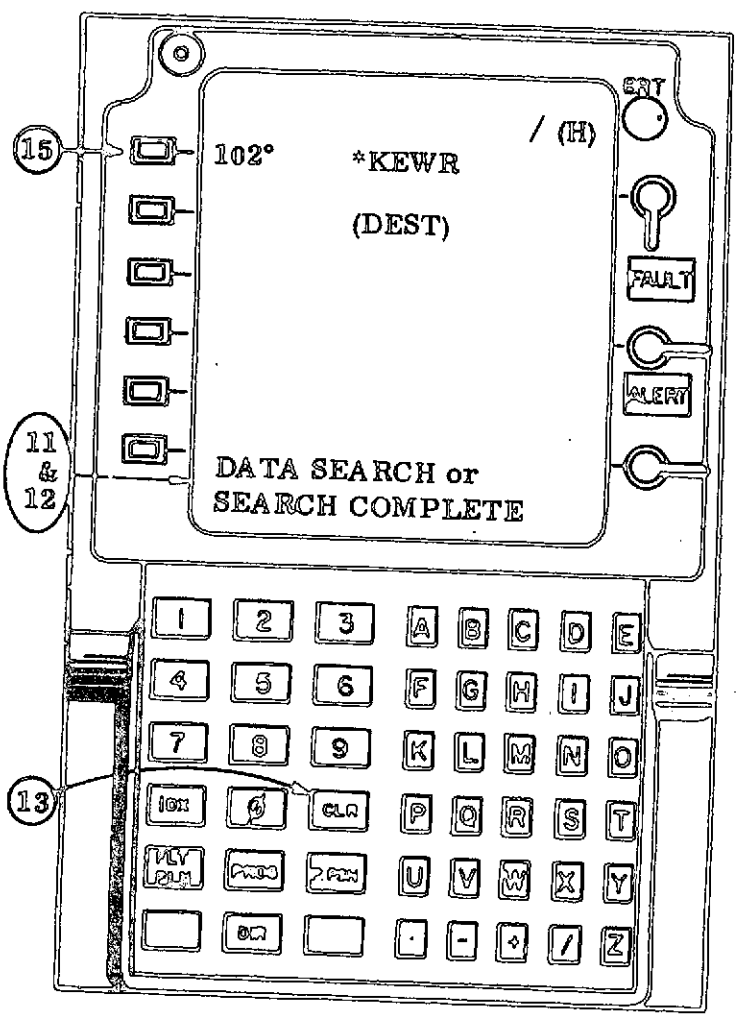
10. A message "PUSH TO ACCESS TAPE" will appear between the origin & destination airports. Push the LINE KEY adjacent to the message.



11. A message "DATA SEARCH" will now appear on the CDU while the tape is being read by the NCU.

12. When the search is completed, a message "SEARCH COMPLETE" will flash on the scratch pad.

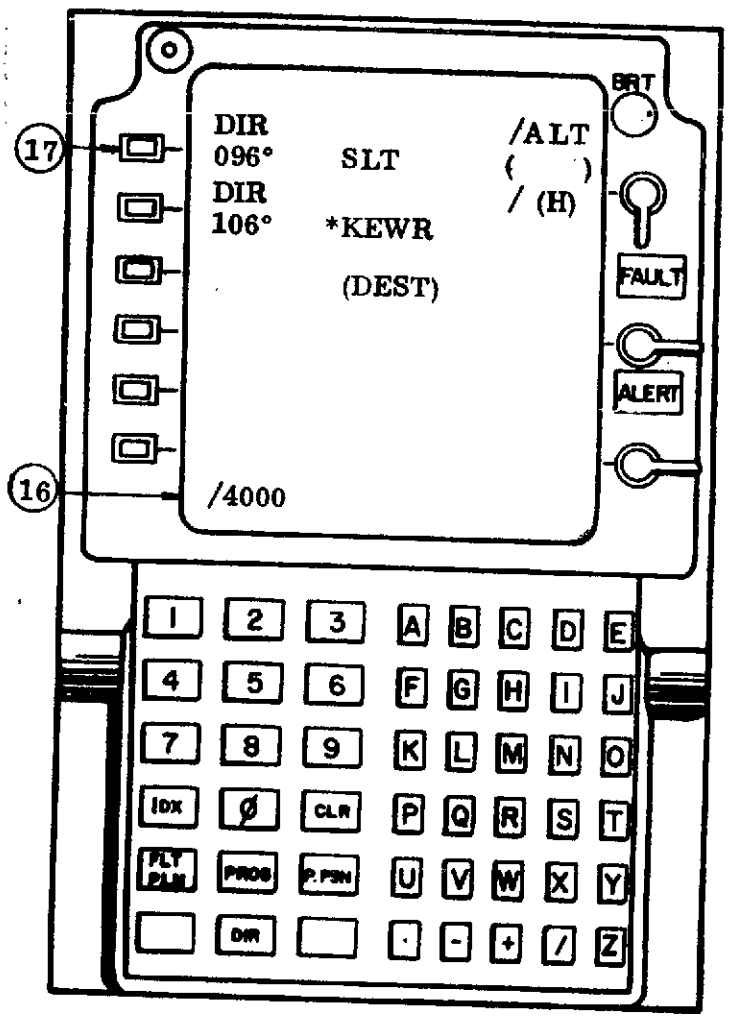
13. Press the CLR key to remove this message from the scratch pad.



14. Type the Update Waypoint (i.e., SLT) on the scratch pad.

15. Insert the Update Waypoint ahead of the destination by pressing the LINE KEY adjacent to the destination airport (KEWR). (See page 6)

16. Edit the Update Waypoint altitude by entering the initial approach altitude at the destination. Write the altitude on the scratch pad (i.e., /4000).



17. Insert the altitude by pressing the LINE KEY adjacent to the Update Waypoint (i.e., SLT).

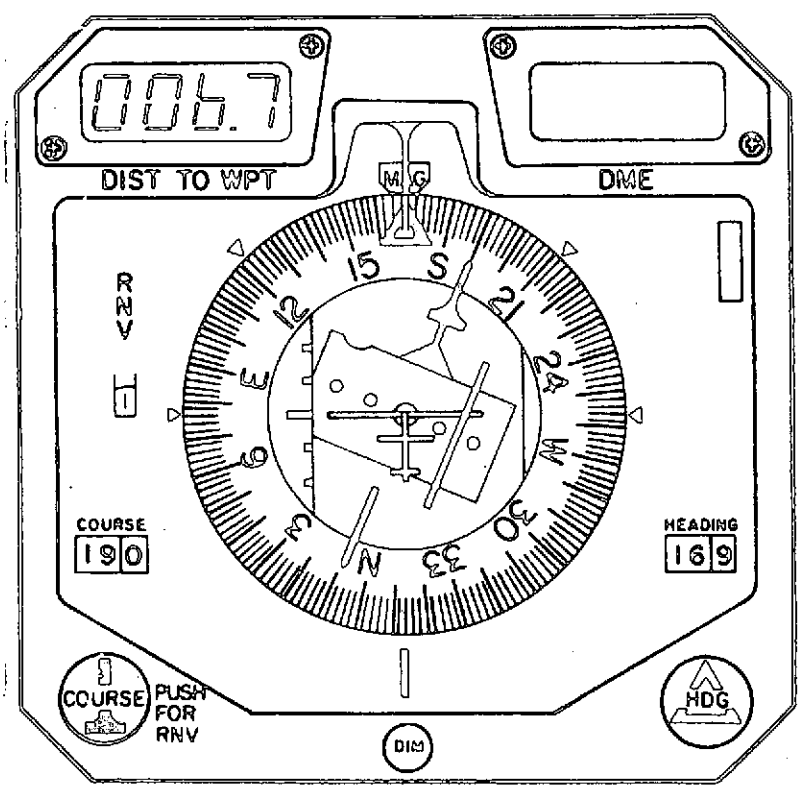
THIS WILL COMPLETE THE FLIGHT PLAN ASSEMBLY.

18. To test the RNAV engage and autotune function:

1. Push in the CI course select knob and check that right hand DME readout goes blank and numerals appear in upper left hand readout for DIST TO WYPT. The GREEN Autotune light located next to the #1 VHF NAV selector will illuminate.

2. Pull course knob out and see that left readout goes blank and right hand DME is illuminated. The Autotune light should go out.

The airplane is now operating on the standard navigation system.

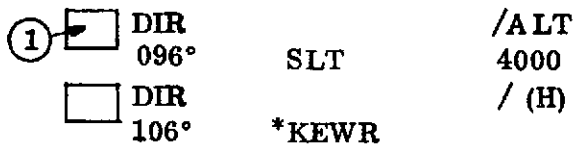


Course Indicator (CI)

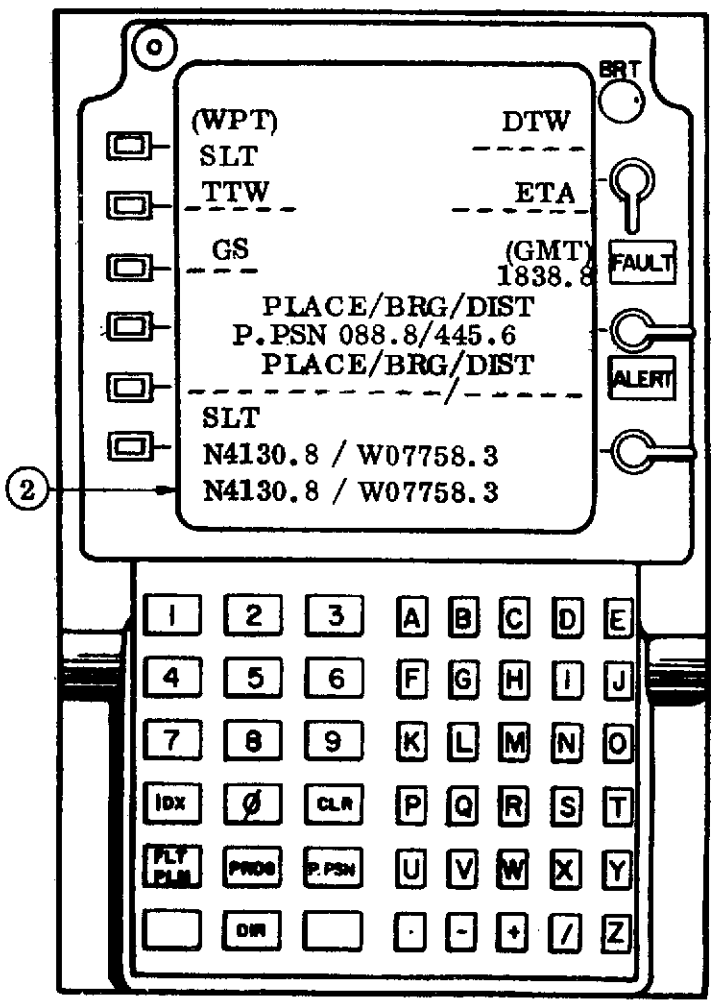
IN FLIGHT UPDATE OF THE RNAV SYSTEM

Prior to reaching the Update Waypoint:

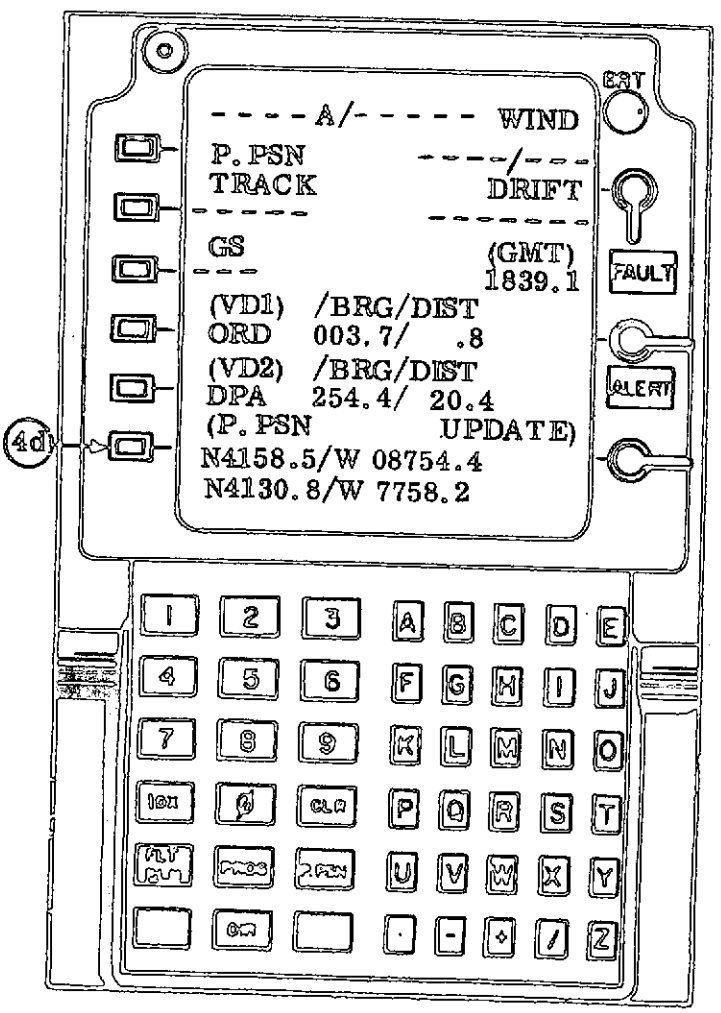
1. Press line key on CDU next to Update Waypoint. This presents Waypoint page on the CDU screen.



2. Copy the LAT/LONG from the Waypoint page onto the scratch pad.



3. Select P. PSN page and observe indicated P. PSN LAT/LONG just above the LAT/LONG written in the scratch pad.



4. Approximately 5 minutes prior to reaching the Update Waypoint (as indicated by the airplane standard navigation system):

   a) Take Autopilot out of VOR/LOC mode (if in use). It may remain in Turn Knob or Heading Mode.

   b) Push in course knob on CI to activate RNAV auto-tuning of radios. Note Autotune light ON.

   c) Observe the present position LAT/LONG display and compare it to the LAT/LONG in the scratch pad as the F/O navigation system indicates waypoint passage. (These coordinates should agree within $\pm$ 2 minutes of latitude and longitude.)

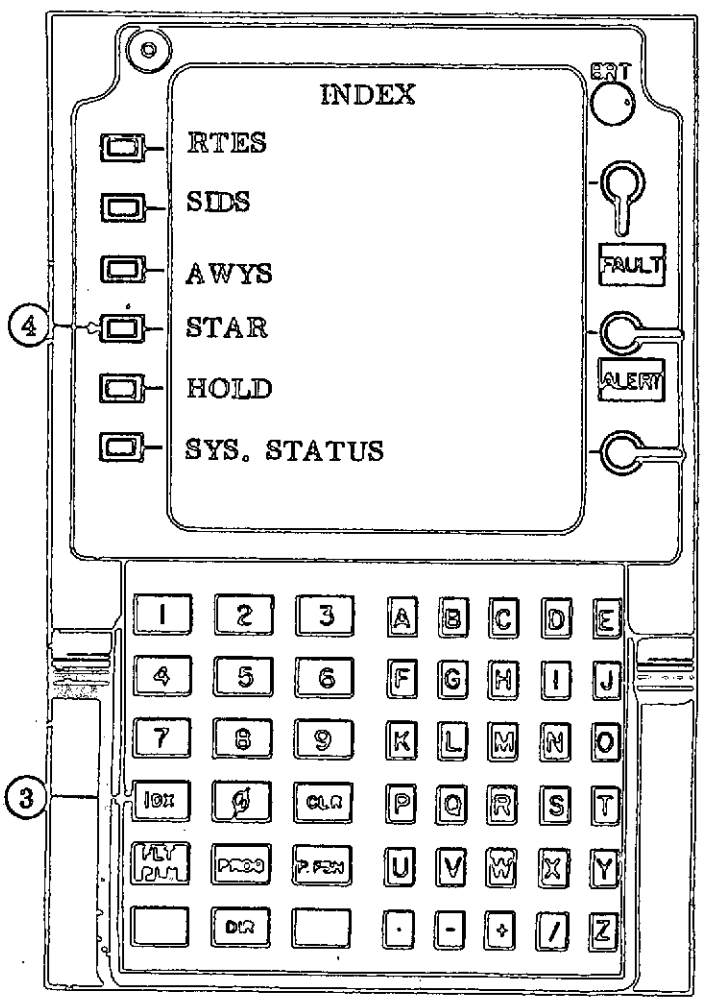
   d) Press LINE KEY next to (P. PSN UPDATE). This will update the LAT/LONG in the computer.

   Observe the wind display in the upper right hand corner of the P. PSN page. Allow it to settle to a steady direction and velocity. (Slow minor changes)

5. Pull the CI course selector knob out and return the airplane to the standard navigation system.

APPROACHING DESTINATION

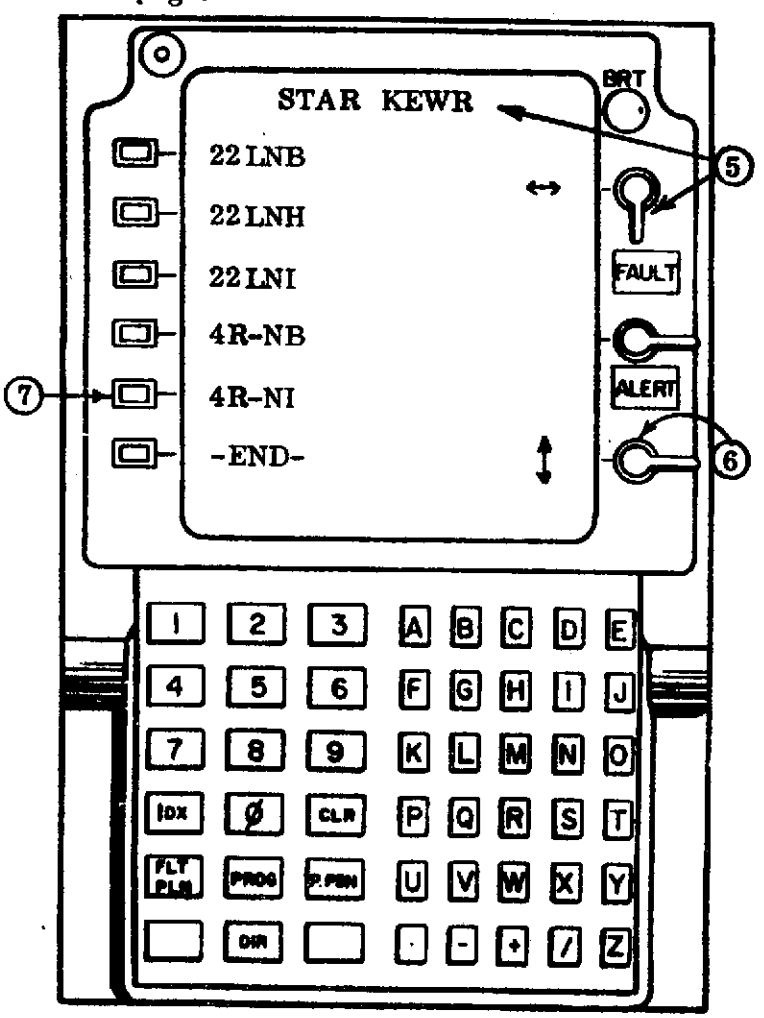
1. After obtaining the ATIS, determine if you intend to fly a Two-Segment Approach and if it will be an RNAV/ILS or RNAV/RNAV.
2. Advise ATC of your intentions.
3. Select [IDX], index page, on the CDU.
4. Press the LINE KEY adjacent to STAR to select the STAR page.



5. Slew left or right to destination STAR page.
   Example: STAR KEWR.

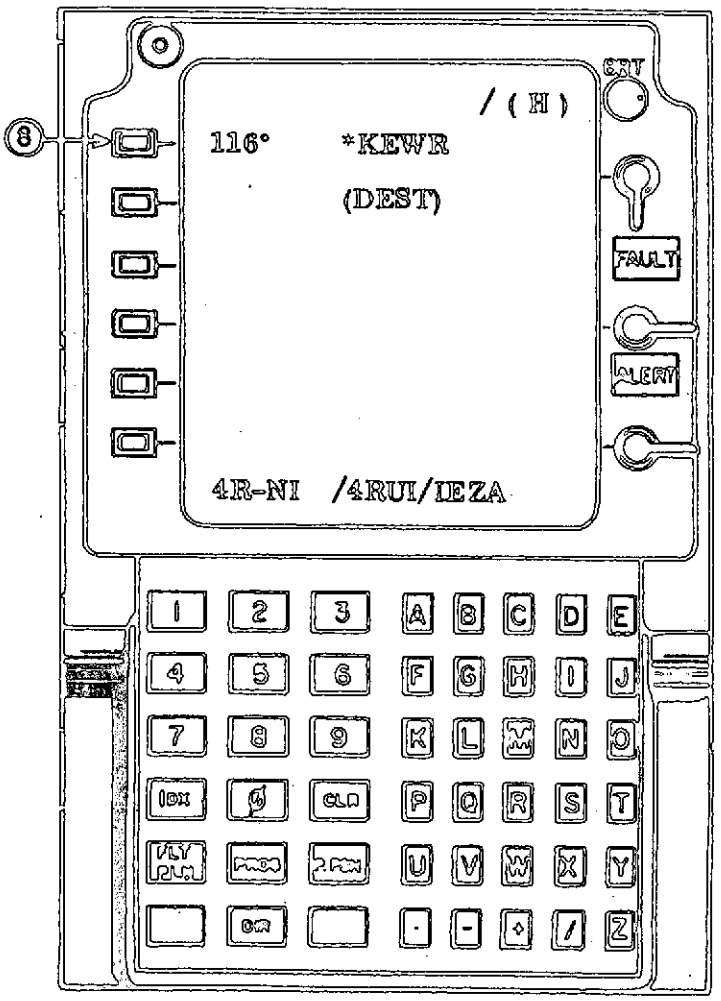
6. Slew the STAR page up to locate the desired approach star.
   Example: RNAV/ILS for runway 4 right at Newark.
   4R-NI.
   NI-Noise abatement RNAV/ILS.
   NB-Noise abatement RNAV/RNAV.

7. Press the LINE KEY adjacent to the desired approach (4R-NI). The approach will appear on the scratch pad and the CDU will automatically switch to the Flight Plan page.



8. Press the LINE KEY adjacent to the destination airport to enter the approach.

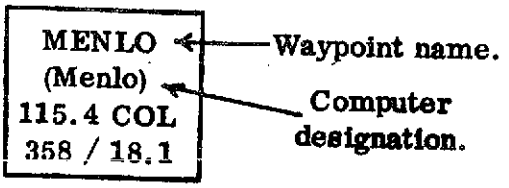
   The CDU screen will indicate UPPER, LOWER, TOUCHDOWN RUNWAY END (TD4R), DEPARTURE RUNWAY END (RW22L).



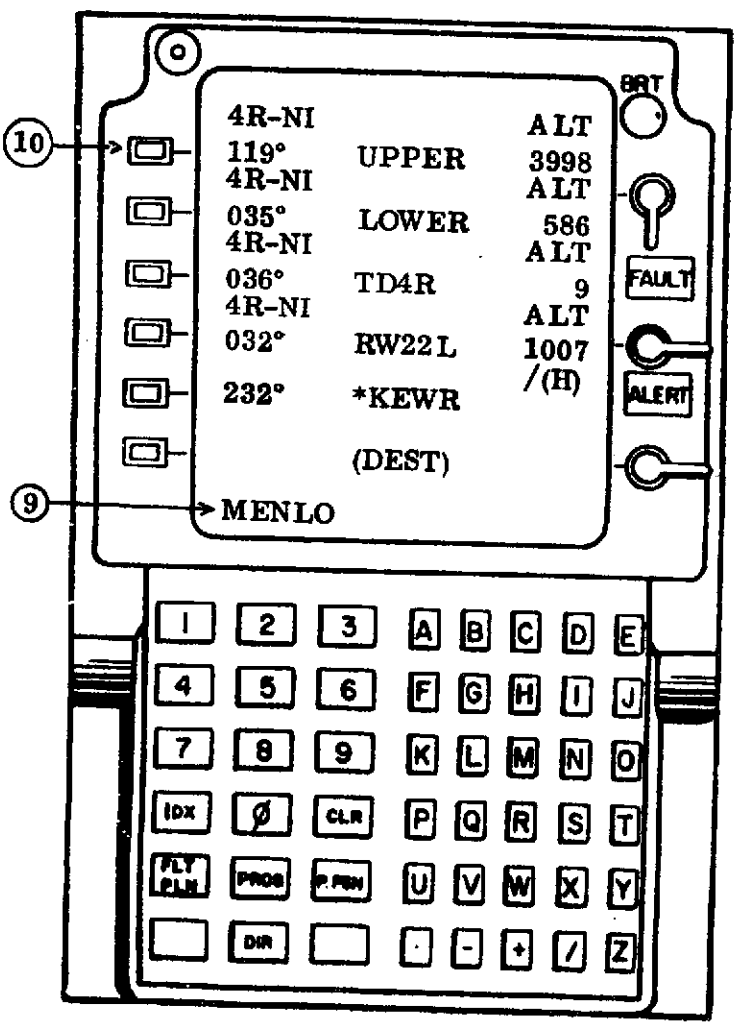
9. Type the name of the Initial Approach Waypoint on the scratch pad.

Note: The waypoint name and the computer designation may not be the same. Use the computer name. This information is found in the waypoint information box in parentheses.

Example:

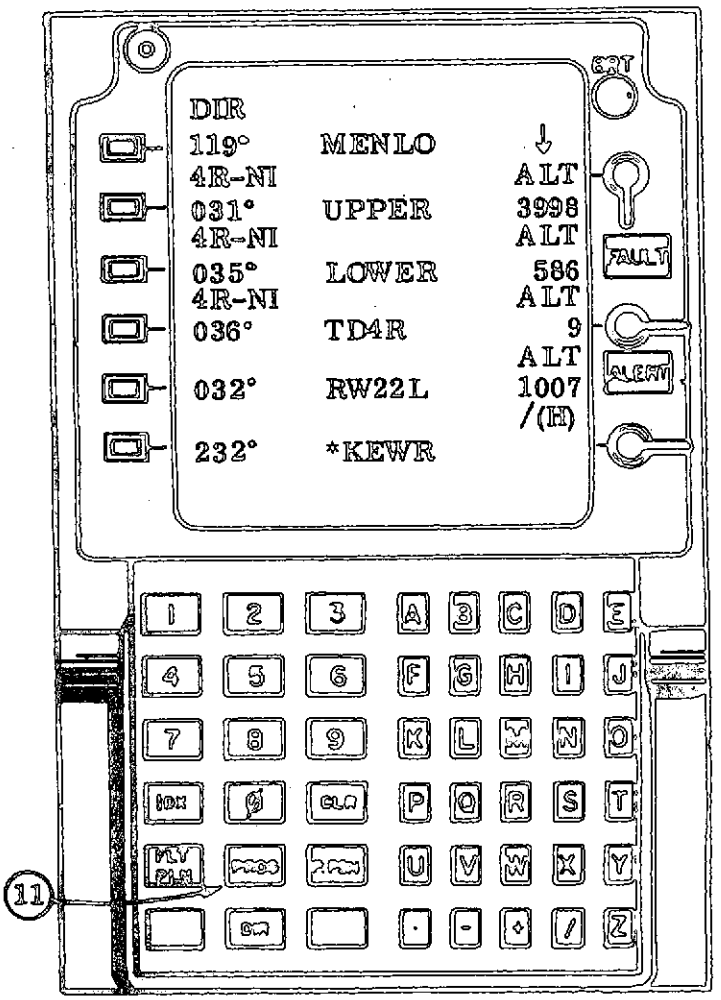


10. Enter the waypoint by pressing the LINE KEY adjacent to UPPER.



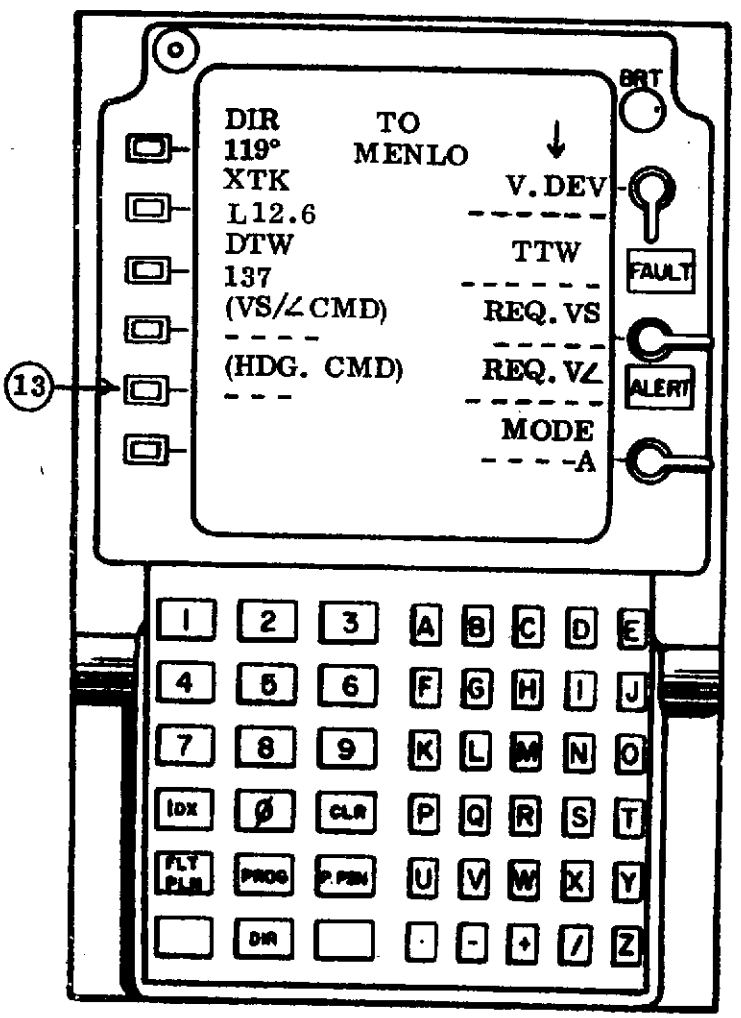
Note: The course to the "TO" waypoint is from the Update Waypoint direct.

11. Select PROG page on the CDU.

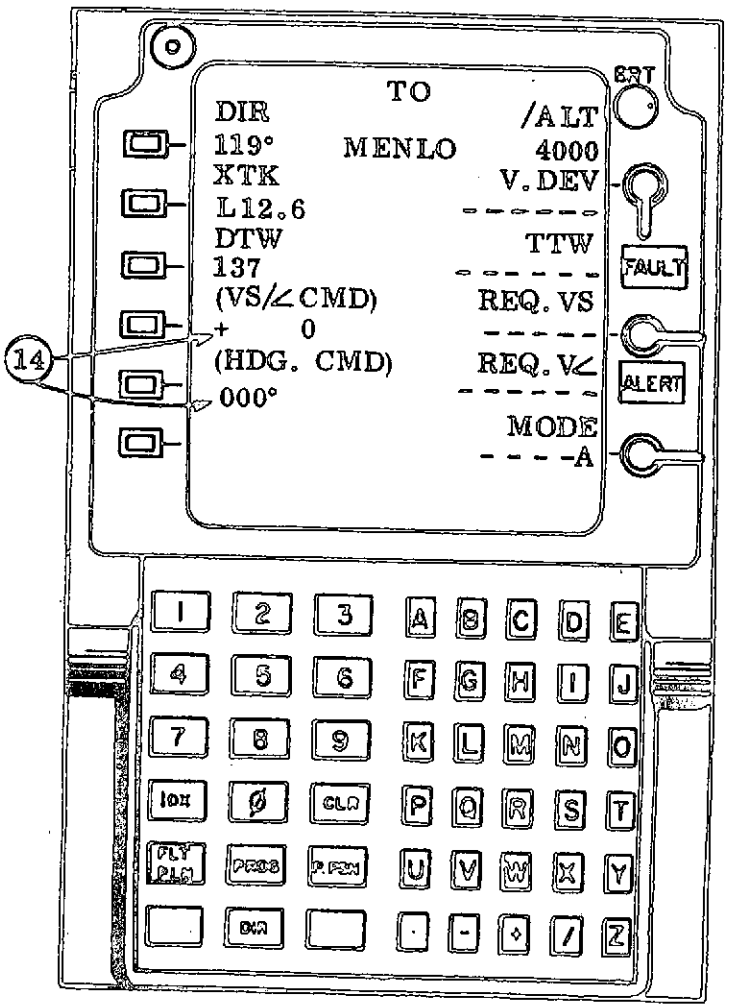


12. Write the initial approach altitude on the scratch pad (i.e. /4000) and enter it at the "TO" waypoint by pressing the top LINE KEY.

13. Select heading command by pressing the LINE KEY adjacent to (HDG. CMD). (5th LINE KEY from the top)



14. The present airplane heading will appear under (HDG. CMD) and the present airplane vertical speed will appear under (VS/∠CMD).

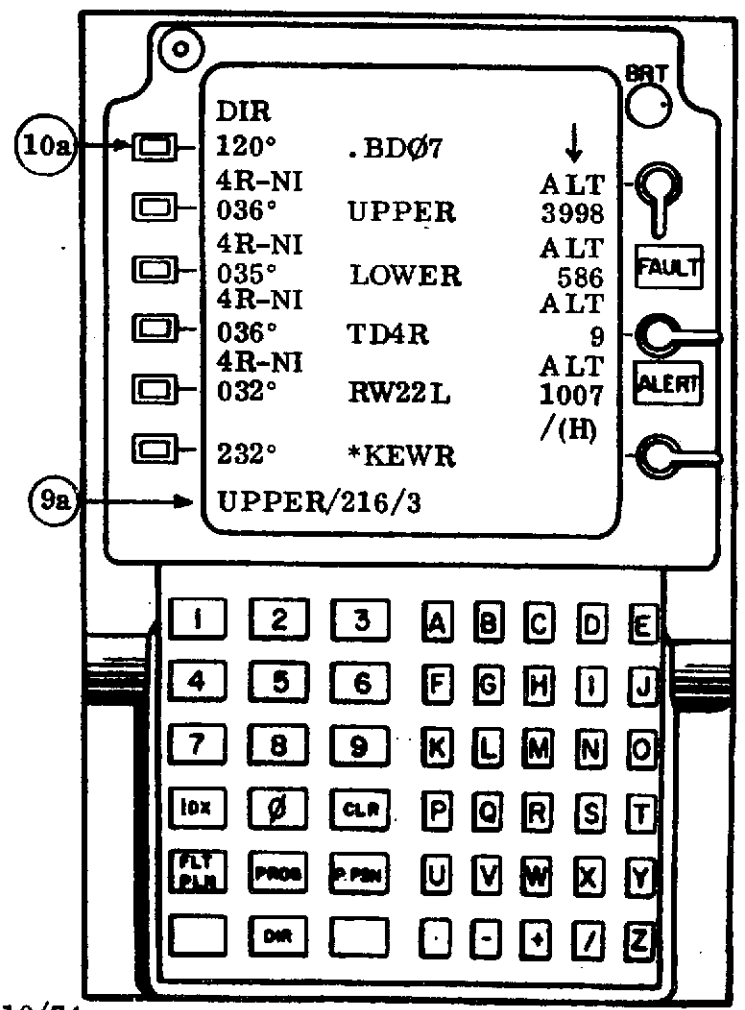


ALTERNATE METHOD for (TO WAYPOINT)

9a. If an intercept point further out than 8 NM is desired or if there is no Initial Approach Waypoint designated for the approach, you must create a course bearing/distance and establish an additional waypoint on the extended runway centerline.

Example: 4R at KEWR Inbound course 036°

Write on the scratch pad UPPER/216° (the reciprocal of the inbound course) /3 (the distance you want to create the waypoint from UPPER). This defines a waypoint by bearing 216° and distance 3 miles from UPPER. The computer will assign a BD identification to this waypoint.



10a. Enter the waypoint by pressing the LINE KEY adjacent to UPPER.

Complete the procedure with steps 11, 12, 13, and 14 (See pages 16 through 18).

IN THE TERMINAL AREA

1. Notify ATC that this is the 2-segment approach airplane and that you desire a 2-segment approach at the initial approach altitude you inserted at the Initial Approach Waypoint.

2. When established on radar vectors, push in the CI course selector knob to activate auto-tuning (Green Autotune light on).

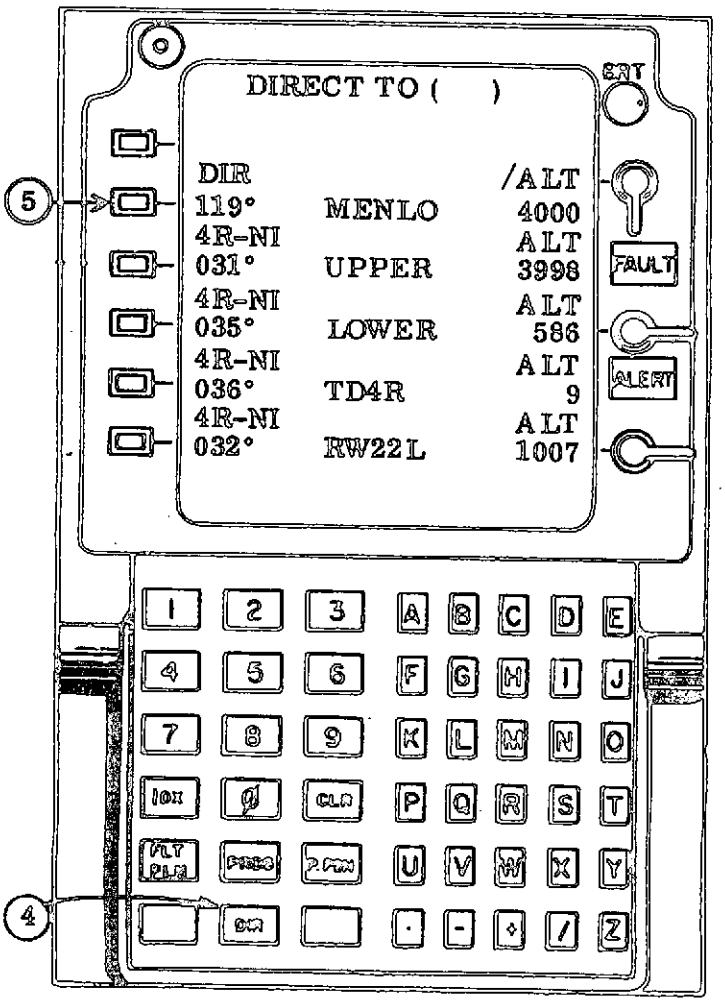
3. The F/I mode on the FD can be used and/or the A/P will operate in TURN KNOB or HDG SEL modes.

   The CI is now indicating the Area Navigation System programmed path in course and altitude to the "TO" waypoint. The Captain's #1 compass needle points to the "TO" waypoint. The DTW on the PROG page and left readout on the Captain's CI indicate the distance from the airplane to the "TO" waypoint.

4a. If an RNAV/ILS approach is to be made, TUNE the #1 VHF NAV radio to the ILS frequency of the approach. NOTE: If this is not accomplished prior to reaching UPPER GREEN, the system will disengage at that point.

4b. If an RNAV/RNAV approach is to be made, DETUNE the #1 VHF NAV radio from an ILS frequency. NOTE: This is so that the AI Glideslope Warning Flag will be in view during the RNAV/RNAV approach.

4. When on the final intercept heading and cleared for the approach, press the DIR key. The CDU will change from the PROG page to the FLT PLN page and DIRECT TO ( ) will appear at the top of the CDU.

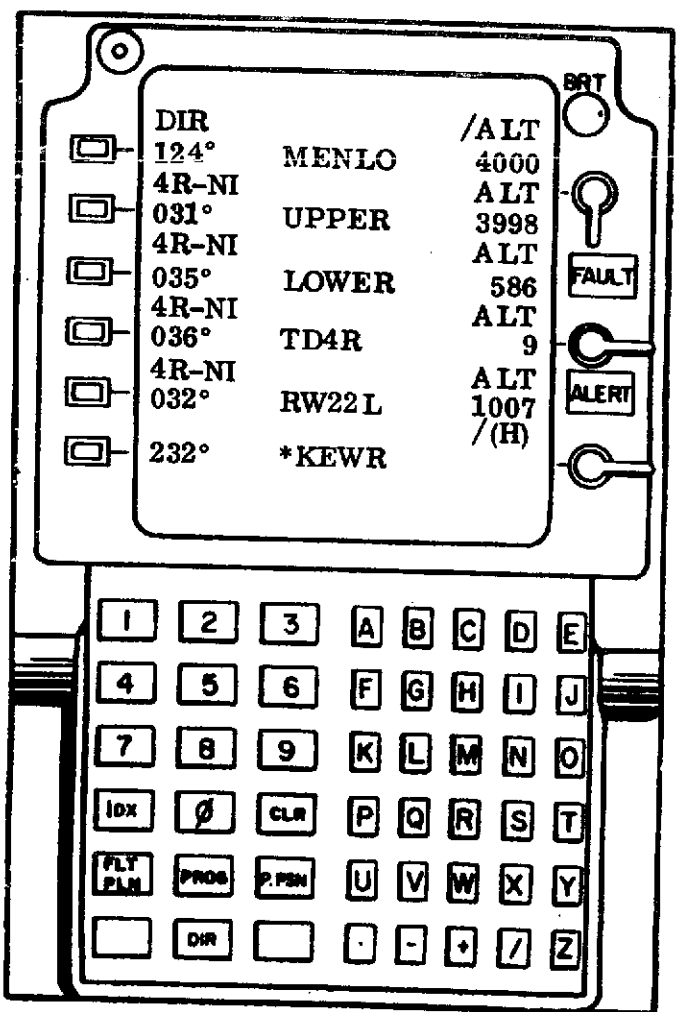


5. Press the LINE KEY adjacent to the "TO" waypoint.

Note:
If the line key for UPPER is pressed and the intercept angle to UPPER is in excess of 60°, an unsatisfactory turn-in and approach may result.

6. The DIRECT TO page on the CDU will change to the FLT PLN page and the "TO" waypoint will be at the top of the CDU.

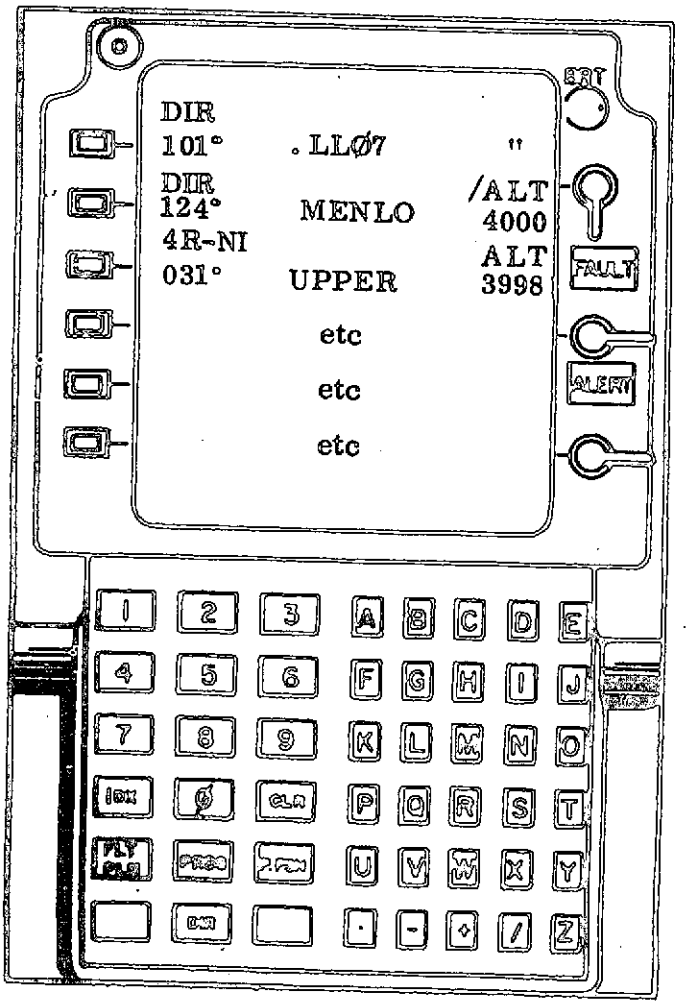
7. Move the F/D Mode Selector to the RNAV Position and follow the command bars for the approach or;



8. If an autocoupled approach is desired: Hold the A/P mode selector in AUX NAV and move the autopilot engage switch to ON.

   Verify that the approach progress display lights come on and change from AMBER to GREEN appropriately.

Note: The computer may create a LAT/LONG turning point when DIRECT TO is used. This will appear on the CDU as shown below. The LL number is assigned by the computer.



LAT/LONG COORDINATES FOR P.PSN ENTRY

AIRPORT	COORDINATES
BOS	N4221.9/W7100.9
DEN	N3945.7/W10453.3
CLE	N4124.5/W8150.4
EWR	N4042.3/W7409.9
IAD	N3856.7/W7726.8
JFK	N4038.3/W7347.8
LAX	N3356.5/W11823.8
ORD	N4158.5/W8754.4
ORF	N3653.7/W7612.1
PDX	N4535.4/W12235.5
RNO	N3930.4/W11946.4
SAN	N3244.0/W11711.7
SCK	N3753.8/W12115.0
SEA	N4726.7/W12218.0
SFO	N3737.2/W12222.9
SLC	N4047.2/W11158.7
YVR	N4911.6/W12310.9

ATTACHMENT #1
5/10/74

APPENDIX F

SUMMARY OF GUEST PILOT QUESTIONNAIRES

Table of Contents - App. F

ANALYSIS OF ACCEPTABILITY OF TWO-SEGMENT RNAV APPROACH FOR LINE OPERATIONS
(19 SIMULATOR - 26 AIRCRAFT QUESTIONNAIRES)

	SIMULATOR	AIRCRAFT
ACCEPTABLE	9	13
CONDITIONALLY ACCEPTABLE	5	10
CONDITIONALLY UNACCEPTABLE	1	2
UNACCEPTABLE	0	1
NOT ASSESSED	4	0
	19	26

NATURE OF PILOT COMMENTS/CONDITIONS RELATING TO LINE OPERATIONS ACCEPTABILITY

ADEQUATE TRAINING/EXPERIENCE	2	13
MORE RESEARCH/TESTING	1	2
ICING/TAILWINDS/ENVIRONMENTAL	4	3
LOWER INTERCEPT/STABILIZATION/PROFILE	1	3
EQUIPMENT RELIABILITY/PRESENTATION	2	7
MINIMUMS	1	2
ATC CONSIDERATIONS	1	3

CONCLUSIONS REGARDING GUEST PILOT OPINION OF THE ACCEPTABILITY OF THE RNAV TWO-SEGMENT APPROACH PROCEDURE IN LINE OPERATIONS:

1. The profile and procedures are acceptable for evaluation in line operations.
2. Adequate pilot training on the RNAV concept and the system will be necessary.
3. Equipment reliability and simplicity of system operation should be improved.
4. Tailwind and icing limitations should be established.

II. SUMMARY OF GUEST PILOT OPINION OF UPPER TRANSITION

	Simulator	Aircraft
TRANSITION OK	15	16
CONDITIONALLY OK	3	9
MARGINAL	0	1

NATURE OF PILOT COMMENTS/CONDITIONS RELATING TO UPPER TRANSITION

1.	Pre-capture configuration/speed cues good.	3	2
2.	Pre-capture configuration/speed problems.	0	3
3.	Tailwinds/Turbulence	1	3
4.	Requires on speed/on path	2	3
5.	Power Problems	0	2
6.	Improved with exposure.	2	1
7.	Almost too easy/gradual.	1	1

SUMMARY OF UPPER SEGMENT STABILIZATION

1.	From upper onward.	0	1
2.	Stabilized if everything centered.	0	1
3.	Shortly after capture.	1	0
4.	When pitch and airspeed established.	0	1
5.	When IVSI established about 1500'/min.	1	1
6.	When configuration completed.	0	1
7.	300'-400' below upper.	1	2
8.	500'-1000' below upper.	1	2
9.	1000'-1500' below upper.	1	2
10.	1500'(AGL)	0	1
11.	Stabilized except power/airspeed.	0	1
12.	Upper stab good due to longer time on segment.	1	0
13.	Not stabilized - too many variables.	0	1

CONCLUSIONS REGARDING PILOT OPINION OF UPPER TRANSITION

1. The upper transition maneuver is acceptable and easy to fly.

2. Entry speed and configuration scheduling for the DC8-61 are important. The procedure and cues make adequate provision for these items.

3. Stabilization on upper segment is accomplished well before lower segment AMBER.

III. SUMMARY OF GUEST PILOT OPINION OF LOWER TRANSITION:

	SIMULATOR	AIRCRAFT
TRANSITION OK	10	18
CONDITIONALLY OK	5	6
MARGINAL	0	3

NATURE OF PILOT COMMENTS RELATING TO LOWER TRANSITION:

1. RNAV/ILS Ok - RNAV/RNAV Questionable.	1	0
2. Power problem.	0	2
3. Thrust/pitch relationships in DC8 assist in transition/transition rate good.	2	2
4. Stabilized too low.	1	2
5. Unstabilized in transition - Ok after.	0	1
6. Lead-in good.	0	2
7. Ok if everything centered.	0	1
8. Concern with engine spool-up/failure.	1	0
9. Wind/Turbulence	1	1
10. Improved with exposure.	1	3

SUMMARY OF LOWER SEGMENT STABILIZATION:

1. Exceeded target airspeed (too much power).	0	1
2. Too low.	0	2
3. Unstabilized in transition - Ok after.	0	1
4. Stabilized if everything centered.	0	2
5. Shortly after lower.	1	0
6. 100'-150' after lower.	0	1
7. 200' " "	1	0
8. 400'-500' (AGL)	2	6
9. When 600'-700'/min IVSI established.	0	2
10. Unstabilized throughout - too many variables.	0	1

CONCLUSIONS REGARDING PILOT OPINION OF LOWER TRANSITION

1. The lower transition is acceptable and easy to fly.
2. Stabilization on glideslope/lower segment is readily accomplished with no significant undershoot tendencies.

IV. SUMMARY OF RECOMMENDED MINIMUMS FOR RNAV/ILS AND RNAV/RNAV (30 PILOTS)

	RNAV/ILS	RNAV/RNAV
No specific recommendation.	11	8
CAT II	7	0
CAT I	1	0
Current ILS	1	0
200'	2	0
300'	1	0
400'-600'	3	6
500'-1000'	1	4
Non-Precision	1	3
VOR	0	3
ADF	0	2
Circling	0	2
VFR	2	2

V. ANALYSIS OF THE SAFETY AND PILOT ACCEPTABILITY OF THE RNAV/ILS APPROACH
(19 SIMULATOR - 27 AIRCRAFT QUESTIONNAIRES)

	Simulator	Aircraft
SAFE	9	17
CONDITIONALLY SAFE	6	7
CONDITIONALLY UNSAFE	1	2
UNSAFE	0	1
NOT ASSESSED	3	0
	19	27

NATURE OF PILOT COMMENTS/CONDITIONS RELATING TO THE RNAV/ILS APPROACH

1. Adequate training/crew coordination.	3	6
2. Further research on minimums/reservations about lower minimums.	1	7
3. Icing/Tailwind/Environmental	2	4
4. Lower intercept/Altitude/Stabilization	1	4
5. Equipment reliability/display-annunciation	4	4
6. Potential degradation of present approach safety margins.	0	1

CONCLUSIONS REGARDING GUEST PILOT OPINION OF THE SAFETY OF THE RNAV/ILS TWO-SEGMENT APPROACH:

1. The RNAV/ILS approach is safe.

2. Adequate pilot training and increased crew coordination will be necessary.

3. Approach minimums will have to be established in the ATC environment.

4. Equipment reliability and presentation should be improved.

5. Environmental conditions limitations should be recognized in the use of this approach.

VI. ANALYSIS OF THE SAFETY AND PILOT ACCEPTABILITY OF THE RNAV/RNAV APPROACH
(19 SIMULATOR - 27 AIRCRAFT QUESTIONNAIRES)

	SIMULATOR	AIRCRAFT
SAFE	5	8
CONDITIONALLY SAFE	8	14
CONDITIONALLY UNSAFE	1	1
UNSAFE	0	3
NOT ASSESSED	5	1
	19	27

NATURE OF PILOT COMMENTS/CONDITIONS RELATING TO RNAV/RNAV APPROACH:

1. Adequate training.	1	0
2. Lower intercept/stabilization altitude	1	1
3. Lateral accuracy.	1	6
4. Icing/Tailwind/Environmental	1	2
5. Equipment reliability.	2	5
6. More research on minimums.	1	5
7. Any non-precision approach is unacceptable for jet operations.	0	1

CONCLUSIONS REGARDING GUEST PILOT OPINION OF THE SAFETY OF THE RNAV/RNAV TWO-SEGMENT APPROACH:

1. The pilot group generally considers the RNAV/RNAV approach safe; however, a substantially larger number have specific reservations about it as compared to the RNAV/ILS.

2. The lateral accuracy of the system should be improved.

3. Equipment reliability should be improved.

4. Approach minimums will have to be established in the ATC environment.

VII. SUMMARY OF PILOT RANKING OF RNAV/RNAV APPROACH WITH CURRENT NON-PRECISION APPROACHES
(30 PILOTS)

NO ASSESSMENT	7
BETTER THAN CURRENT NON-PRECISIONS	6
EQUAL TO CURRENT NON-PRECISIONS	9
BETTER THAN ONE OR MORE CURRENT NON-PRECISIONS	4
RANKS WITH ADF	3
INFERIOR TO CURRENT NON-PRECISIONS	1
	30

NATURE OF PILOT COMMENTS RELATED TO RANKING OF RNAV/RNAV AND CURRENT NON-PRECISION APPROACHES

1.	More research/reservations about lower minimums.	14 Comments
2.	Vertical guidance in RNAV/RNAV is desirable as compared to current non-precisions.	6 "
3.	Lateral accuracy of RNAV/RNAV is inferior to current (particularly VOR and back course).	7 "
4.	RNAV/RNAV approach consistency/reliability questionable.	4 "
5.	Any non-precision approach unacceptable for jet aircrafts.	1 "

CONCLUSIONS REGARDING GUEST PILOT RANKING OF RNAV/RNAV AND CURRENT NON-PRECISION APPROACHES:

1. The RNAV/RNAV is a non-precision approach.

2. As a procedure, it ranks well with the current non-precision approaches.

3. The RNAV/RNAV vertical guidance is an advantage over the other procedures.

4. Lateral accuracy and consistency are questionable.

5. Considerable further investigation regarding approach minimums will be necessary.

VIII. SUMMARY OF GUEST PILOT COMMENTS ON RNAV INSTRUMENTATION

A. APPROACH PROGRESS DISPLAY

	Simulator	Aircraft
1. Display Ok.	15	22
2. Needs differentiation between RNAV/ILS and RNAV/RNAV.	3	1
3. Add Altitude Hold Annunciation.	2	1

B. ADI

1. Cover Raw G/S Indicator or bias from view when not furnishing information.	5	6
2. Bias F/D pitch command bar from view on G/A; G/A logic incomplete.	3	6
3. Color contrasts poor in instrument.	10	2
4. Ok - No Changes.	3	9

C. HSI

1. Ok - No Changes.	5	10
2. Data switch at lower capture/data display logic.	2	4
3. Object to color of green bar.	1	3

D. RECOMMENDED OVERALL INSTRUMENTATION CHANGES

1. Cover or bias raw G/S in ADI when not in use.	5	9
2. Go-around logic/improve presentation.	1	6
3. Improve instrument color contrast.	4	0
4. HSI data switch logic at lower capture.	1	2
5. No changes.	1	9

CONCLUSIONS RELATED TO GUEST PILOT EVALUATION OF RNAV INSTRUMENTATION

1. The Approach Progress Display is meaningful and acceptable.

2. The ADI display is generally acceptable, except that the raw deviation information should be covered or biased from view when it is not furnishing useable information.

3. The HSI display is acceptable. Vertical deviation reference switching from upper segment to glideslope at lower capture with the attendant disparity between Flight Director "fly up" and HSI/ADI raw data "fly down" is cited as objectionable and/or dangerous by about 15% of the pilot group.

4. Overall instrument display is generally acceptable except for the concerns enumerated in (2) and (3) above.

IX. SUMMARY OF SIMULATOR RANKING QUESTIONNAIRES AND WRITTEN COMMENTS

RANKED ITEM	Standard ILS Approach			RNAV Two-Segment Approach	
	Significantly Easier	Slightly Easier	No Difference	Slightly Easier	Significantly Easier
A. Autopilot Usage		4 (17%)	18 (75%)	1 (4%)	1 (4%)
B. Flight Dir. Following	1 (4%)	9 (40%)	12 (52%)	1 (4%)	
C. Instrument Interpretation	3 (13%)	13 (54%)	7 (29%)	1 (4%)	
D. Flt. Progress Annunciation		9 (39%)	8 (35%)	5 (22%)	1 (4%)
E. Inst. Scanning Requirements	5 (22%)	10 (45%)	8 (33%)		
F. Airspeed Control		14 (61%)	8 (35%)	1 (4%)	
G. Flap Management		2 (8%)	20 (84%)	2 (8%)	
H. Trim Control	1 (4%)	7 (30%)	15 (62%)	1 (4%)	

A. AUTOPILOT USAGE

(1) Ranked ILS easier because pilot more familiar with ILS procedure. (1 comment)

B. FLIGHT DIRECTOR FOLLOWING

(1) Lack of color contrast on ADI made precise tracking more difficult on two-segment approach. (1 comment)

(2) Flight Director gain in simulator poor. (2 comments)

C. INSTRUMENT INTERPRETATION

(1) Ranked ILS easier because pilot more familiar with ILS procedure. (1 comment)

(2) Two-segment more difficult because additional items to keep track of. (1 comment)

D. FLIGHT PROGRESS ANNUNCIATION

(1) Ranked ILS easier because pilot more familiar with ILS annunciation. (1 comment)

(2) Approach Progress Display makes approach easier to follow than with standard DC-8 annunciations. (1 comment)

(3) Annunciations would be as easy as ILS after 5-10 hours exposure. (1 comment)

(4) APD excellent. Could be improved by the addition of an ILS Glide-slope Arm/Capture annunciator below present LOWER SEGMENT annunciator. This would serve to differentiate between RNAV/RNAV and RNAV/ILS. (1 comment)

E. INSTRUMENT SCANNING REQUIREMENTS

(1) Different data displayed on HSI and ADI resulted in more concentration on airspeed and altitude and searching for corroborative deviation data. (1 comment)

(2) Standard ILS easier workload. (1 comment)

(3) More things to scan on two-segment approach. (1 comment)

F. AIRSPEED CONTROL

(1) Pilot unwilling to make necessary power adjustment at upper capture resulted in excessive pitch and airspeed control to correct back to upper segment. (1 comment)
(2) Throttle friction too high (auto throttles installed). (1 comment)
(3) Lower transition makes overall power control more difficult. (1 comment)
(4) Closer attention to airspeed on upper segment more difficult. (1 comment)
(5) ILS and two-segment approximately same if approximate thrust settings are known in advance. (1 comment)

GENERAL

Doesn't like vertical deviation reference change from upper to lower/glideslope on HSI. (1 comment)

Bias raw glideslope out or cover on ADI when not providing useable information. (1 comment)

Likes two-segment approach/easy to fly/feasible. (3 comments)

Further evaluation necessary. (2 comments)

Training required/improvement with experience. (3 comments)

Most critical area is disparity between HSI deviation display ("Fly-Down") and Flight Director command ("Fly Up") at lower capture and transition. Feels this represents potential for flying thrcugh glide-slope at upper segment descent rate at low altitude. Would like to see HSI deviation continue to display deviation from computed lower transition path. (1 comment)

Believes removal of pitch guidance at 500'(AFL) on RNAV/RNAV is disturbing. Recommends display should continue both vertically and laterally to MDA then hold level at MDA until reaching Approach Runway Waypoint then continue to Missed Approach holding via some wings level point in vicinity of far end of runway. (1 comment)

X. SUMMARY OF AIRCRAFT RANKING QUESTIONNAIRES AND COMMENTS

RANKED ITEM	RNAV TWO SEGMENT APPROACH		
	Acceptable	Conditionally Acceptable	Unacceptable
(Indicate below the level of acceptability of the ranked items.)			
A. Autopilot Usage	21 (92%)	2 (8%)	
B. Flight Dir. Following	17 (71%)	7 (29%)	
C. Instrument Interpretation	14 (61%)	8 (35%)	1 (4%)
D. Flt. Progress Annunciation	19 (83%)	4 (17%)	
E. Inst. Scanning Requirements	16 (70%)	6 (26%)	1 (4%)
F. Airspeed Control	20 (87%)	3 (13%)	
G. Flap Management	20 (87%)	2 (9%)	1 (4%)
H. Trim Control	19 (83%)	4 (17%)	
I. Pre-App. Cockpit Set-up	14 (61%)	7 (31%)	2 (8%)
J. Radio Communications	20 (95%)	1 (5%)	
K. Check List Management	19 (90%)	2 (10%)	
L. CDU Presentation	11 (55%)	8 (40%)	1 (5%)

A. AUTOPILOT USAGE (No comments)

B. FLIGHT DIRECTOR FOLLOWING

(1) Pitch command portion not clearly annunciated as to commanding data source. (1 comment)

(2) Pitch bar gives too much command for the correction needed. (2 comments)

(3) Pitch bar did not give sufficient command to re-capture upper segment after deviating. (1 comment)

(4) More difficult to cross check vertical deviation on HSI and Flight Director command at lower transition. Found vertical raw data easier than F/D pitch command. (1 comment)

C. INSTRUMENT INTERPRETATION (4 comments)
(1) Cover ADI raw glideslope or bias from view when not furnishing useable information.
(2) Overall presentation (including instruments and CDU) lacking. (1 comment)

D. FLIGHT PROGRESS ANNUNCIATION
(1) Not explicit enough. Out of scan. (1 comment)
(2) Good display. (1 comment)

E. INSTRUMENT SCANNING REQUIREMENTS
(1) Additional monitoring for lower transition is no problem except for requiring different concentration sequence. (1 comment)
(2) Upper and lower transitions acceptable to fly after familiarization; however, requires greater instrument scan than standard ILS.
(3) Use of command bar and ADI raw glideslope requires too much time to interpret. (1 comment)

F. AIRSPEED CONTROL
(1) Auto throttles slow resulting in going below glideslope about 1 dot. (1 comment)
(2) Final airspeed needs to be established at upper capture and maintained throughout. (1 comment)

G. FLAP MANAGEMENT
(1) "Dirtying airplane on upper segment will pour profits out the tailpipe." (1 comment)

H. TRIM CONTROL (No comments)

I. PRE-APPROACH COCKPIT SET-UP
(1) More basic RNAV info needed. (1 comment)
(2) Considers unsatisfactory for terminal operations due to too many ATC variables. (1 comment)
(3) Too easy to insert wrong approach when clearance changes and have minimum time to make change. Approach should be identified by runway - NO CODES. (1 comment)
(4) System too complicated for simple RNAV navigation. (1 comment)

J. RADIO COMMUNICATIONS (No comments)

K. CHECK LIST MANAGEMENT
(1) Causes distraction during the approach. (1 comment)

L. CDU PRESENTATION
(1) More basic RNAV info needed. (1 comment)
(2) CDU should incorporate hand rest to steady hand when operating keyboard in turbulence. (1 comment)
(3) CDU too close to elevator manual trim handles. (1 comment)
(4) Will require considerable training for required understanding. (1 comment)

(5) Will take too long to become proficient in operation. (1 comment)
(6) Keyboard could be better arranged. Page indication should be presented. (1 comment)
(7) Flight following information such as groundspeed, wind, cross track angle and error, drift should all be on one page. (1 comment)
(8) CDU presentation very helpful in maintaining awareness of position and location. (1 comment)

GENERAL

1. Missed approach program incomplete. (2 comments)

2. HSI deviation not compatible with aircraft climb performance on missed approach. (1 comment)

3. Deviations from flight plan must be accomplished well before the approach. (1 comment)

4. Did not feel he was able to contribute to other cockpit duties while flying the RNAV two-segment approach. (1 comment)

5. Additional time required to operate RNAV and CDU in order to obtain full benefit of system. (1 comment)

6. Reliability of RNAV system/interface questionable. (1 comment)

DC8/RNAV GUEST PILOT COMMENT SUMMARY

APPROACH ANALYSIS

DC-8/RNAV GUEST PILOT COMMENT SUMMARY

PART I - APPROACH ANALYSIS

PILOT	SIM A/C	RNAV 2-SEGMENT: RNAV 2-SEG NORMAL LINE OPS? WHY?	RNAV/ILS: RNAV/ILS SAFE? WHY?	RNAV/ILS: MINS	RNAV/RNAV: RNAV/RNAV SAFE? WHY?	RNAV/RNAV: MINS	TRANSITIONS/STAR: UPPER & LOWER
	S	Simulator Problems.	Simulator Problems	-	Simulator Problems	-	Simulator Problems.
#1	A	No - not as presently staged. U/S angle excessive - lower transition abrupt, too low.	(No) Marginal - should intercept lower seg at higher alt.	400-1	(No)- not below ADF min Equates to ADF.	ADF	(Ok) - felt stab, but does not like low power...UPPER LOWER: Poor - stab ok after transition.
#2	S	Yes - assuming navaids will provide the needed data.	Yes - when functioning properly	CAT II	(Yes) Depending on approach minimums, should be as safe as any non-precision. Equates to ADF.	Prob. 500/1	UPPER: Provides ample warning and permits smooth entry. Stab 500-600 below upper. LOWER: No problem - more rapid than 727 - stab about 500'.
	A	Yes - Adequate safeguards are provided.	Yes. (No comment)	CAT II	Yes. Mins depend on runway - 500/1 if no obstruction problem. Equates to ADF	500/1	UPPER: Good - stab 300-400' below upper. LOWER: Smooth - stab 400-500'.
#3	S	Yes - U/S angle ok - engine power in descent ok - in icing should consider using STD ILS- this ok because small percentage of total.	(Yes)- more research required to establish mins.	-	(Yes)- more research required.	-	UPPER: No problem - stab shortly after upper. LOWER: No problem - stab shortly after lower.
	A	Yes - It is not difficult. Can be flown by properly trained crew member.	(Yes)- More approaches and evaluations needed to establish mins.	-	(Yes)- More approaches and evaluations required to establish mins. RNAV/RNAV safer than other non-precisions because vertical guidance is available.	-	- -

F-14

DC-9/RNAV GUEST PILOT COMMENT SUMMARY

PART I - APPROACH ANALYSIS

		RNAV 2-SEGMENT	RNAV/ILS		RNAV/RNAV		TRANSITIONS/STAR
[illegible]	STD A/C	RNAV 2-SEG NORMAL LINE OPS? WHY?	RNAV/ILS SAFE? WHY?	MINS	RNAV/RNAV SAFE? WHY?	MINS	UPPER & LOWER
#4	S	Yes. No more difficult.	Yes. With adequate training.	-	Yes, with adequate training.	-	UPPER: Good, proper warning. LOWER: Good, almost too easy.
#5	S	Simulator Problems	Simulator Problems	-	Simulator Problems	-	(Ok) if ATC permits desired intercept speed...UPPER LOWER: Ok RNAV/ILS. Questionable RNAV/RNAV.
	A	Yes, with adequate training and crew call-outs. Unfamiliarity with various instrument indications and annun.	Yes. (No comment)	-	Yes. (No comment)	-	UPPER: (Ok) if on speed approaching upper. LOWER: Ok - tended to add too much thrust/exceed target speed.
#6	S	(No) Wind shear/anti-ice 500' stab alt restrict to VFR.	(No) - Need dual system with captain capability to select #2 system.	VFR	(No) - Better than current "Time to MAP", ADF, VOR, etc. If MDH is 350' below lower stabilized point.	VFR	UPPER: Good - better than 727 as to transition from initial config/speed to landing config. LOWER: Good - better than 727 relative to thrust/pitch/trim requirements.
	A	(No) not without a decrement in safety - too close to DH when sink rate, crab angle, thrust & IAS established. Eng. A/I not adequate with tailwind.	No, lower stabilized point too low in adverse WX. Anti-ice capability inadequate for WX.	-	No. (See RNAV/ILS)		UPPER: smoother lead-in than 727 - not too abrupt. LOWER: Stabilized too close to DH. In WX should be stab as high above DH as in STD ILS.

DC-8/RNAV GUEST PILOT COMMENT SUMMARY

PART I - APPROACH ANALYSIS

		RNAV 2-SEGMENT	RNAV/ILS		RNAV/RNAV		TRANSITIONS/STAB
[redacted]	SIM A/C	RNAV 2-SEG NORMAL LINE OPS? WHY?	RNAV/ILS SAFE? WHY?	MINS	RNAV/RNAV SAFE? WHY?	MINS	UPPER & LOWER
#7	S	No Sim Questionnaire	-	-	-	-	-
	A	(?) (8) Unable to state because: (1) Acft mix between STD and 2-seg; (2) Wake Vortex; (3) Training costs; (4) Relative merits of 2-seg vs minimum drag G/S approach to 1000' or below.	Yes - with adequate crew training: 8 hrs. equip ground school, 1 sim period, 1 acft period.	200' (if stab on G/S)	(Yes) - but not during parallel approaches. Equates to ADF. Course and G/S guidance not adequate for lower min	500'	UPPER: (Ok) as familiarity with waypoints improved. Stab ok except descent from 4000'AFL exposes A/C to more wind shears. LOWER: Better than expected.
#8	S	No Sim Questionnaire	-	-	-	-	-
	A	(Yes) - Pilot training & proficiency essential. Proven thru usage in ATC environment.	Yes - (No comment)	Cur. ILS mins	Yes - Prefers RNAV/RNAV to ADF & VCR.	ADF (now)	UPPER: Well programmed - pitch not excessive. Stab when pitch and A/S estab. LOWER: Lead-in info adequate. Needs more practice.
#9	S	Not assessed in sim.	Yes. -	CAT II	Yes. -	-	UPPER: Good - stab at 3000' AFL. LOWER: Good - stab at 500' AFL.
	A	Yes. (No comment)	Yes. (No comment)	CAT II	Yes - Equates to other non-precision.	Non-Prec.	UPPER: Good - stab at 3000'. LOWER: Good - stab at 500'.

DC-8/RNAV GUEST PILOT COMMENT SUMMARY

PART I - APPROACH ANALYSIS

RANK	SIM A/C	RNAV 2-SEGMENT: RNAV 2-SEG NORMAL LINE OPS? WHY?	RNAV/ILS: RNAV/ILS SAFE? WHY?	RNAV/ILS: MINS	RNAV/RNAV: RNAV/RNAV SAFE? WHY?	RNAV/RNAV: MINS	TRANSITIONS/STAR: UPPER & LOWER
# 10	S	(Yes) With restrictions: WX, traffic mix, wake turbulence.	(Yes) - except in icing, tailwinds, restrict to high mins until equipment reliability and pilot familiarity established.	-	(Yes) - except icing, tailwinds. Equates to other current non-precisions.	Non-Prec.	UPPER: Ok. LOWER: Ok.
	A	(Yes) - with restrictions as above.	(Yes) - except icing, tailwinds (high mins as above).	-	(Yes) - except icing, tailwinds. Equates to other non-precision approaches.	Non-Prec.	UPPER: (Ok) - feels stab as long as everything is centered. LOWER: (Ok) - Same as upper.
# 11	S	(Yes) - Should be line tested. Concern about engine spool up below 1000'AFL.	Yes. (No comment)	CAT I & II	Yes - Consideres better than other non-precisions with possible exception back course.	Non-Prec.	UPPER: Very easy. At first not stab. Got used to it - very smooth. LOWER: Very easy (same as above).
	A	(Yes) - more line testing.	Yes. (No comment)	CAT I	(?) Needs more experience to form honest opinion.	-	UPPER: No problem - easy to accomplish. Felt he needed more training and practice. Stab from upper capture on. LOWER: (Same as upper)

DC-8/RNAV GUEST PILOT COMMENT SUMMARY

PART I - APPROACH ANALYSIS

		RNAV 2-SEGMENT	RNAV/ILS		RNAV/RNAV		TRANSITIONS/STAB
[redacted]	S/D A/C	RNAV 2-SEG NORMAL LINE OPS? WHY?	RNAV/ILS SAFE? WHY?	MINS	RNAV/RNAV SAFE? WHY?	MINS	UPPER & LOWER
#12	S	Yes - Does it VFR now.	Yes. (No comment)	-	Yes. (No comment)	-	UPPER: No problem. LOWER: Not stated (see equipment eval).
	A	Yes - Does it VFR now.	Yes. "	-	Yes. "	-	UPPER: No problem. LOWER: See equipment eval.
#13	S	Yes. (No comment)	Yes. "	-	Yes. "	-	UPPER: Nice transition - F/D leads a little too much. LOWER: (Same as upper.)
	A	Yes. "	Yes. "	-	Yes. "	-	UPPER: Nice transition - no problem. LOWER: (Same as upper.)
#14	S	Yes. Workload only slightly higher than STD ILS.	Yes. "	ILS	(Yes) From operational view only accuracy questionable.	500'	UPPER: No problem F/D or A/P. Stab 300-400' after upper. LOWER: No problem F/D or A/P. Stab about 200' after lower.
	A	Yes - Mins adjustable to expected navaids errors. Equip reliability not considered.	Yes. (No comment)	CAT II	Yes. Prefers RNAV/RNAV because of vertical guidance. Permits stable approach.	500/1	UPPER: No problem. LOWER: No problem.

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DC-9/RNAV GUEST PILOT COMMENT SUMMARY

PART I - APPROACH ANALYSIS

		RNAV 2-SEGMENT	RNAV/ILS		RNAV/RNAV		TRANSITIONS/STAR
NAME	SIM A/C	RNAV 2-SEG NORMAL LINE OPS? WHY?	RNAV/ILS SAFE? WHY?	MINS	RNAV/RNAV SAFE? WHY?	MINS	UPPER & LOWER
#15	S	(No Sim Questionnaire)					
	A	(No) Most pilots can fly procedure on-line ok. Procedure is paced and evaluated by pilots generally more capable than least competent pilot.. Must be capable of being safely flown by least competent pilot. Present procedure and system potentially degrade already thin margins of safety which exist in current day approaches.	(No) Can be flown acceptably by most pilots. Two-segment approach represents potential degradation of already thin safety margins. Mins should be at least 200' above lower transition.	800-2	No. Pilot feels that any non-precision approach is unacceptable for commercial jet aircraft. Equates RNAV/RNAV with other non-precisions.	VFR	UPPER: Easy, gradual-almost too gradual. Did not feel stabilized until 1500'(AGL). LOWER: Occurs too low. Takes too long to stabilize on lower segment of approach Stabilized 400'-500'(AGL).

DC-8/RNAV GUEST PILOT COMMENT SUMMARY

PART I - APPROACH ANALYSIS

		RNAV 2-SEGMENT	RNAV/ILS		RNAV/RNAV		TRANSITIONS/STAR
SIM	SIM A/C	RNAV 2-SEG NORMAL LINE OPS? WHY?	RNAV/ILS SAFE? WHY?	MINS	RNAV/RNAV SAFE? WHY?	MINS	UPPER & LOWER
#16	S	(Yes) - Conditions: (1) Proper ground trng on RNAV equipment. (2) Practice approaches prior to line flying.	Yes. (No comment)	500' -700'	(Not assessed in sim)	-	UPPER: Good transition-smooth, no big pitch-over. Stabilized ok. LOWER: No problems with
	A	(Yes) - Conditions: (1) Grnd trng on RNAV. (2) Grnd trng on 2-seg. concept. (3) Practice approaches before on-line.	Yes. (No comment)	400' -600'	No - Feels needs more testing for approaches to 500'-700'. Approaches not consistant. Mins dependent on terrain. Would rank below ADF at this time	500-700' to 1000'	UPPER: Very smooth. Good transition. Stab. ok. LOWER: No problems. After a couple of approaches could anticipate power advance. Stab. ok.
#17	S	Yes. Improved visual instrumentation is principal area of need.	Yes. Approach is safe. Visual instrumentation sub-standard - fam. required for this app.	300' 3/4	(Yes) As a non-precision approach only. Ranks RNAV/RNAV within limits of other non-precisions.	Circ.	UPPER: Satisfactory - stab ok. LOWER: Satisfactory - stab ok.
	A	Yes. (Same as above)	Yes. Requires more crew coordination to monitor approach effectively.	300' 3/4	(Yes) For circling mins only. Approaches inconsistent. Ranks with non-precisions.	Circ.	UPPER: Satisfactory - stab ok. LOWER: Satisfactory - stab ok.
#18	S	YES - Use pilot discretion. VLM min - no.	Yes. (No comment)	200' ½	(Yes) - Check on instr. reliability. Ranks RNAV/RNAV with back course.	500/1	UPPER: Ok. LOWER: Ok.
	A F-20	(Yes) - VFR or VOR mins. DC8 power off-chasing G/S and airspeed.	Yes - Reliability questionable.	Vis. Ldg. Mins	(Yes) Bench set Hoe Bar bias off at 500'. Equates RNAV/RNAV to VOR/Back Course. Subject to system reliability.	-	(UPPER:) Does not like power off - IFR over the top. Always working - never really estab. for any length of time (Comment related to unfamil. acft.) (LOWER: Ok) (Stab same.

DC-9/RNAV GUEST PILOT COMMENT SUMMARY

PART I - APPROACH ANALYSIS

NAME	SIM A/C	RNAV 2-SEGMENT: RNAV 2-SEG NORMAL LINE OPS? WHY?	RNAV/ILS: RNAV/ILS SAFE? WHY?	RNAV/ILS: MINS	RNAV/RNAV: RNAV/RNAV SAFE? WHY?	RNAV/RNAV: MINS	TRANSITIONS/STAR: UPPER & LOWER
	S	No Sim. Questionnaire	-	-	-	-	-
#19	A	(Yes) - with possible restrictions: (1) environmental (2) System performance (3) Level of automaticity; (4) level of total sys reliability (which may limit mins (grnd & air).	(Yes) - Needs study for mins.	-	(Yes) - with appropriate mins. Need more info on sys performance & reliability to estab. mins. States RNAV easier than other non-precisions.	-	UPPER: No problem - stab 300-500' after upper capture. LOWER: Smooth and very easy. Stab 100-150' after lower capture.
	S	No Sim Questionnaire	-	-	-	-	-
#20	A	(Yes) - Factors (1) If RNAV ILS; (2) Training required; (3) Selected airports; (4) Coupled or F/D. Would like to have flown without 25/35 KTS wind and turbul.	Yes. CAT II if procedure specifies on speeds all the way.	CAT II	(Yes) - Rates RNAV/RNAV about same as other non-precisions. Can be off laterally and still show on on RNAV/RNAV.	Circ.	(UPPER:) Smooth, easy. Started a little early at 1½ dots where gear is lowered. Nose pitches before gear is locked. Have to wait for flaps. Speed control impaired. Stab 1000-1500' after upper capture. LOWER: Smooth, easy. Small throttle advance and trim change within friction band. Stab by 400' Radalt.

DC-8/RNAV GUEST PILOT COMMENT SUMMARY

PART I - APPROACH ANALYSIS

		RNAV 2-SEGMENT	RNAV/ILS		RNAV/RNAV		TRANSITIONS/STAR
SIM	SIM A/C	RNAV 2-SEG NORMAL LINE OPS? WHY?	RNAV/ILS SAFE? WHY?	MINS	RNAV/RNAV SAFE? WHY?	MINS	UPPER & LOWER
#21	S	(Yes)- Subject to: (1) Sys reliability. (2) High minimums. (3) Smoothness.	(Yes) Feels there is possibility that G/S stabilization in gusty conditions not good enough for lower mins.	200' ½	(Yes)- Very experience limited. RNAV/RNAV ranked similiar to other non-precisions.	500' or 5000' RVR	UPPER: Very smooth - good stab. when IVSI about 1500'/min. (LOWER:) Good but uncertain about stab on G/S for low mins. Usually stab except in variable wind or gusty.
	A	Yes. Based on limited experience with RNAV.	Yes. (No comment)	200' ½ - 2400 RVR	(Yes) Would prefer VOR guidance and RNAV vertical commands. Equates RNAV/RNAV about same as other non-precision	500/1 RVR 5000	UPPER: Good - used rate of descent as stab indicator. LOWER: Good - used G/S on lower as stab indicator.
#22	S	Not assessed in sim.	Not assessed in sim.	-	Not assessed in sim.	-	UPPER: Same as transition to ILS. (LOWER:) No problem under normal conditions. Questions situation if engine does not spool up or fails at this point.
	A	Yes. Provided system operates normally.	(Yes) To present mins.	-	Yes - ranks RNAV/RNAV better than other non-precisions.	500/1	UPPER: Same as ILS transition. LOWER: No problem under normal conditions.

DC-9/RNAV GUEST PILOT COMMENT SUMMARY

PART I - APPROACH ANALYSIS

		RNAV 2-SEG/LOC	RNAV/ILS		RNAV/RNAV		TRANSITIONS/STAR
NAME	SIM A/C	RNAV 2-SEG NORMAL LINE OPS? WHY?	RNAV/ILS SAFE? WHY?	MINS	RNAV/RNAV SAFE? WHY?	MINS	UPPER & LOWER
#23	S	No Sim Questionnaire	-	-	-	-	-
	A	(Yes) - if following acceptably determined: 1. Programming 2. Annunciation 3. Accuracy & repeatability of sensor input.	(Yes) Provided thoroughly disciplined approach procedure is monitored. Annun. should clearly indicate whether localizer and VOR is updated info or whether air data is being used to compute path. Under ideal conditions experienced crew could go to 100'. If on air data, minimums should be raised as a function of how long since last update.	-	(Yes) - Computer is capable of fine discrimination. The presentation to the pilots reflects the degree of programming accuracy and the quality, accuracy and consistency of the sensory inputs used for update purposes. Suggest factor present-day non-precision minimums to give new captains chance to gain experience. RNAV/RNAV should be superior to other non-precisions particularly back course. Wants further testing to prove.	High Mins	(UPPER:) Good - an awkward period following upper seg capture and intercept requiring airspeed reduction. Required about 500' below upper to stab airspeed. Tailwind component complicates this task. LOWER: Good - for consistency, at lower mins, a power required indication from the speed command system would add assurance if displayed on the ADI somehow. Would help upper transition.
#24	S	No Sim Questionnaire	-	-	-	-	-
	A	Yes - with sufficient trng and experience. Factors: Training, Experience, Simplicity of RNAV.	Yes - with proper orientation and trng.	CAT II	(Yes) - Only for high mins. Rates RNAV/RNAV no different to fly. Lateral accuracy not as good as VOR or back course. As good as ADF.	600/1	UPPER: No problem - capture logic very good and easy to follow except F/D pitch bar did not provide sufficient command to re-capture. Stab 500'-1000' below upper. LOWER: Good, eas to capt. & maintain reg. G/s. Stab at 300' AFL.

DC-8/RNAV GUEST PILOT COMMENT SUMMARY

PART I - APPROACH ANALYSIS

		RNAV 2-SEGMENT	RNAV/ILS		RNAV/RNAV		TRANSITIONS/STAB
[redacted]	SIM A/C	RNAV 2-SEG NORMAL LINE OPS? WHY?	RNAV/ILS SAFE? WHY?	MINS	RNAV/RNAV SAFE? WHY?	MINS	UPPER & LOWER
#25	S	(Not assessed)	(Yes) Concerned about height of lower stab under adverse wind - has open mind pending further flt testing.	Not Belo VOR mins	(Yes) Back-up cross check of lateral pos. such as DF desirable. VOR mins with other lateral back-up. RNAV/RNAV presents more desired info than other non-precisions because of vertical guidance.	VOR	(UPPER:) Not difficult as flown. Potential difficulties if higher intercept speeds due to oversight or ATC requirement. Believes correct speed essential. Stabilized better on upper seg. due to longer period to stab. LOWER: Auto-coupled/auto-throttle no apparent difficulties. Manual transition more difficult. Reserves judgment on lower stab until fly aircraft.
	A	(Yes) With higher mins. Lateral inaccuracies without lateral cross check info.	(Yes) - with trained crews and reasonable flt. conditions. Has reservations about CAT I mins.	500' 400'	(Yes) - With reasonable minimums. Back-up for distance, alt checks (possibly Radalt cross check). Mins variable with speeds - faster speeds requiring more visibility.	-	(UPPER:) Not difficult provided speeds are reasonably close to target (20-25 KTS over) as G/S bar comes into view. Stab 300'-400' below upper, about 500' with auto-throttle. (LOWER:) Under average wind conditions, transition lead-in adequate. Workload greater with manual throttle or F/D & man. throttle with wind shear condition. Stab 400'-500' AFL.

DC-8/RNAV GUEST PILOT COMMENT SUMMARY

PART I - APPROACH ANALYSIS

		RNAV 2-SEG NORMAL	RNAV/ILS		RNAV/RNAV		TRANSITIONS/STAR
MR	SIM A/C	RNAV 2-SEG NORMAL LINE OPS? WHY?	RNAV/ILS SAFE? WHY?	MINS	RNAV/RNAV SAFE? WHY?	MINS	UPPER & LOWER
	S	No Sim Questionnaire					
#26	A	(Yes) - Subject to: (1) Acceptable trng. (2) Line check. (3) Proficiency in CDU operation. (4) Flt tested and designated approved apps. (5) Deviation display mods (see equip eval.). (6) Study of commonality/differences btwn enroute and terminal displays/procedures.	(Yes) - Provided vertical deviation display logic incorporated. (See equip eval.)	Init 250/ 3/4 then 100/ 1200	(Yes) - Provided: 1. VOR minimums. 2. Each designated app. is flt tested. Lower than VOR mins after flt test of app proves lower mins safe. Ranks RNAV/RNAV better than other non-precisions. Lateral/vertical guidance and position vastly improved.	VOR	(UPPER:) No problems except with high tailwinds. Stab except power & airspeed. (LOWER:) Numerous power adjustments are required, but the vertical profile is readily flyable. Stab except power/airspeed.
	S	No Sim Questionnaire					
#27	A	Yes - Conditions: 1. Training program must show the "good & the bad" so pilot can evaluate each RNAV/RNAV approach to its fullest	Yes - Standard jet minimums.	-	(Yes) - Considers RNAV/RNAV much better than ADF. Equal to VOR/back course ILS. Except for course deviation, vertical profile better in RNAV/RNAV than VOR/back course ILS.	500' -800'	UPPER: Very easy. Stab on gear and flap extension. LOWER: Power pitch on DC8-61 causes smooth pitch up with far less power and pitch changes than anticipated. Stab on G/S after 600'-700' sink rate established.

DC-8/RNAV GUEST PILOT COMMENT SUMMARY

PART I - APPROACH ANALYSIS

PNR	STS A/C	RNAV 2-SEGMENT RNAV 2-SEG NORMAL LINE OPS? WHY?	RNAV/ILS RNAV/ILS SAFE? WHY?	MINS	RNAV/RNAV RNAV/RNAV SAFE? WHY?	MINS	TRANSITIONS/STAR UPPER & LOWER
#28	S	No Sim Questionnaire	-	-	-	-	-
	A	Yes - training of crews and ATC will be a major factor.	Yes - Basic jet mins until line evaluated.	-	(Yes) - To higher mins. Considers RNAV/RNAV better than ADF but not as precise or consistent as VOR or back course.	500'-800'	UPPER: Good in training reference to DME to upper would be helpful in programming drag. Wind factors should be considered. Stab when gear down, flaps 50° and airspeed and power stabilized. LOWER: Very smooth - stab as soon as sink rate and power established.
#29	S	Yes - Additional pilot training required.	(Yes) - On basis of limited exposure.	-	(Not assessed in Sim)	-	(UPPER:) Could be a problem in adverse WX - tailwinds, updrafts which could induce U/S overshoot. LOWER: (Same as upper)
	A	No A/C Questionnaire					

DC8/RNAV GUEST PILOT SUMMARY

INSTRUMENTATION ANALYSIS

DC-8/RNAV GUEST PILOT COMMENT SUMMARY

PART II - INSTRUMENTATION ANALYSIS

		APPROACH PROGRESS DISPLAY	ADI	HSI	OVERALL INSTRUMENT DISPLAY
	SIM/ACFT	MEANINGFUL?/INTERPRETATION? RECOMMENDED CHANGES?	SATISFACTORY? IF NOT, WHY?	ACCEPTABLE? IF NOT, WHY?	RECOMMENDED CHANGES
#1	S	-	(No Sim Questionnaire).	-	-
	A	Ok - no changes.	Satisfactory.	Ok after training and experience.	No changes.
#2	S	Acceptable but inferior to 727 annunciator. In-range lights (RNAV Amber) not meaningful because IP is within Green range (Sim problem).	Ok.	Ok.	DME in difficult position. (Simulator configuration artificiality.)
	A	Ok - no changes.	OK	Ok.	No changes.
#3	S	Yes. No changes.	(Yes) Contrast between command bars and aircraft symbol should be increased G/S indicator should be out of view when it is not required.	Yes.	Glideslope bar on ADI from view when not required.
	A	Yes - no changes.	(Yes) G/S indicator from view when not required.	Yes.	(Same as above.)
#10	S	Ok - no changes.	1. Display of G/S flag and G/S indicator simultaneously is disconcerting. 2. Acft symbol on face of instrument should align with G/S center or be swept so as not to confuse with G/S center.	-	DME is out of scan (simulator configuration artificiality.)
	A	OK - no changes.	(Same as Sim comment.)	-	Recommends MAP display to replace HSI.

DC-8/RNAV GUEST PILOT COMMENT SUMMARY

PART II - INSTRUMENTATION ANALYSIS

RUN	SIM A/C	APPROACH PROGRESS DISPLAY MEANINGFUL?/INTERPRETATION? RECOMMENDED CHANGES?	ADI SATISFACTORY? IF NOT, WHY?	HSI ACCEPTABLE? IF NOT, WHY?	OVERALL INSTRUMENT DISPLAY RECOMMENDED CHANGES
#4	S	Yes. No Changes	Flag should cover raw G/S data indicator	-	Eliminate raw data G/S from ADI (flag to cover display would be best).
	A	-	(No aircraft questionnaire)	-	-
#5	S	For training, should be more like aircraft.	Flt Director command bar vs background contrast is poor.	-	-
	A	No changes.	Bias F/D pitch command bar from view for go-around.	-	Program RNAV to go over far end of runway before turning to a missed approach way-point. Bias F/D pitch com-mand bar from view for go-around.
#6	A	Out of scan, should be closer to ADI/HSI.	Bias G/S bar from view when not furnishing G/S info.	Dist. to wypt. too re-mote from principal instrument (ADI).	1. Better than sim. 2. Bias G/S bar out of ADI when not furnishing G/S info. 3. Dist to wypt too remote.
	S	1. Out of scan - should be closer to ADI/HSI where info is presented. 2. Add F/D alt hold annun when pitch command is in alt hold mode. 3. Needs better words than just "RNAV" in the top annunciator.	1. Color contrast between F/D command bars and back-ground. 2. G/S bar out of view if not furnishing G/S info. 3. Dist to wypt closer (or in) ADI.	"Dist to Wypt" too remote.	(See ADI)

DC-8/RNAV GUEST PILOT COMMENT SUMMARY

PART II - INSTRUMENTATION ANALYSIS

PILOT	SIM A/C	APPROACH PROGRESS DISPLAY MEANINGFUL?/INTERPRETATION? RECOMMENDED CHANGES?	ADI SATISFACTORY? IF NOT, WHY?	HSI ACCEPTABLE? IF NOT, WHY?	OVERALL INSTRUMENT DISPLAY RECOMMENDED CHANGES
#11	S	Ok - would prefer the L-1011 black or white tumbler type.	Not satisfactory because steering dot is hidden behind steering bars.	No comment.	Believes vertical tape Radalt is superior. Digital alt readout and round dial with pointers is best.
	A	Ok - (Same as above)	ADI in acft much easier to steer by with large orange dot.	No comment.	(Same as above.)
#7	S	(No Sim Questionnaire)	-	-	-
	A	Ok - no changes.	Ok - no changes.	Ok - no changes.	No changes.
#8	S	(No Sim Questionnaire)	-	-	-
	A	Ok - adequate.	Ok - essential cross-check info available.	Ok - no changes.	No changes.
#9	S	Ok - no change	Ok - no change	Ok - no change	No changes.
	A	Ok - no change	Ok - no change	Ok - no change	No change.
#12	S	Would like to see go-around mode selected with auto-pilot disconnect switch.	Would like to see ADI & HSI indicators both showing upper segment and both switch to lower seg at lower armed.	(See ADI)	(See APD & ADI)
	A	Ok - no change.	During RNAV/RNAV would like to see G/S indicator blanked out (covered).	-	(See ADI)

DC-9/RNAV GUEST PILOT COMMENT SUMMARY

PART II - INSTRUMENTATION ANALYSIS

NAME	SIM A/C	APPROACH PROGRESS DISPLAY MEANINGFUL?/INTERPRETATION? RECOMMENDED CHANGES?	ADI SATISFACTORY? IF NOT, WHY?	HSI ACCEPTABLE? IF NOT, WHY?	OVERALL INSTRUMENT DISPLAY RECOMMENDED CHANGES
#13	S	Need to display whether in RNAV/RNAV or RNAV/ILS mode. Could be displayed elsewhere if necessary.	1. Heading bug should be some bright color. 2. Bright color for command bars would be an improvement.	-	(See APD/ADI)
	A	Ok - no change	Remove G/S indicator in RNAV/RNAV.	-	General presentation in A/C much better than simulator.
#14	S	Ok - would like ILS lower segment differentiated from RNAV computed L/S.	Mask G/S indicator when not receiving signals.	Ok - no change.	(See APD & ADI)
	A	(Same as Sim above)	Ok	Ok	No changes.
#19	S	-	Lack of color contrast makes precise tracking more difficult.	-	-
	A	Ok - no change at this time.	Ok.	Ok.	No changes.
#20	S	Annunciations make approach easy to keep track of	-	-	-
	A	Ok - no change.	Not satisfactory - roll bar good; pitch bar needs damping or reduce error displacement.	No satisfactory - G/S bar should be white - should show only G/S deviation, not alt deviation.	1. Progress display nearer ADI. 2. Vertical Radalt.

DC-8/RNAV GUEST PILOT COMMENT SUMMARY

PART II - INSTRUMENTATION ANALYSIS

[illegible]	SIM A/C	APPROACH PROGRESS DISPLAY MEANINGFUL?/INTERPRETATION? RECOMMENDED CHANGES?	ADI SATISFACTORY? IF NOT, WHY?	HSI ACCEPTABLE? IF NOT, WHY?	OVERALL INSTRUMENT DISPLAY RECOMMENDED CHANGES
	S	(Not assessed in Sim)			
#15	A	Meaningful and easy to interpret on final approach course. (1) Lower amber should illuminate immediately after upper green. Five mile false lobe protection is still needed, but no annunciation to pilot is needed. (2) RNAV amber should illuminate when pilot selects approach and not at 30-mile or other arbitrary point. (3) Need more positive malfunction indication than presently provided. (4) Autopilot disengage lights should be in same place as APD. (5) Unmistakable indication of A/P or F/D failure needed. (6) Provisions for glideslope capture prior to localizer capture should be provided to cope with late vectors on to approach course.	(1) Barely satisfactory in sim - not large, clear or precise enough. (2) Needs more pitch graduations. (3) Color contrasts poor. (4) F/D too busy in pitch. (5) Wings level go-around command potentially dangerous in assymetrical thrust case. (6) Heads-up display would be beneficial to preclude the head down requirements in 500'(AGL) regime. (7) Raw glideslope in ADI not needed because it is too small. (8) Objects to disparity between deviation data and flight director commands in lower transition regime. (Fly down vs fly up) Elimination of raw glideslope in ADI will make pilot reference. HSI more frequently to determine actual position in space with respect to glideslope center.	Ok - color coding on glideslope bar is good. Would prefer MAP display to HSI.	(See APD and ADI)

DC-9/RNAV GUEST PILOT COMMENT SUMMARY

PART II - INSTRUMENTATION ANALYSIS

#	SIM/A/C	APPROACH PROGRESS DISPLAY MEANINGFUL?/INTERPRETATION? RECOMMENDED CHANGES?	ADI SATISFACTORY? IF NOT, WHY?	HSI ACCEPTABLE? IF NOT, WHY?	OVERALL INSTRUMENT DISPLAY RECOMMENDED CHANGES
#16	S	No problem - very easy to interpret. No changes.	Cover raw data or bias it out when not furnishing useable information.	No satisfactory in Sim. Course bar indicator lags behind or ahead of bank steering bar on ADI.	(See ADI)
	A	Ok - No problems.	(Same as Sim comment above)	Ok in aircraft.	(See ADI)
#17	S	Satisfactory - no changes.	Satisfactory for Sim work. See A/C comments.	Acceptable - See A/C comments.	See A/C comments.
	A	Satisfactory - no changes.	ADI becomes too "primary" and seemed to intarrupt or reduce panel scan required for the approach.	Difficult to include in overall panel scan.	Visual display could be significantly improved.
#18	S	Ok - no changes.	Color contrast of cross bars.	Could be larger.	Needs more time.
	A	Ok - no problem.	For RNAV approach would use G/S inop flag and some type of indication that approach is RNAV (assume intends to say RNAV/RNAV).	What does green bar look like at night?	No changes.

DC-8/RNAV GUEST PILOT COMMENT SUMMARY

PART II - INSTRUMENTATION ANALYSIS

		APPROACH PROGRESS DISPLAY	ADI	HSI	OVERALL INSTRUMENT DISPLAY
		MEANINGFUL?/INTERPRETATION? RECOMMENDED CHANGES?	SATISFACTORY? IF NOT, WHY?	ACCEPTABLE? IF NOT, WHY?	RECOMMENDED CHANGES
#21	S	Ok - brightness should be controllable.	Pitch command bar too sensitive in Sim. Bias G/S indicator out when not in use.	Ok - Green bar may be hard to see under some lighting conditions.	1. Bias G/S from view in ADI when not in use. 2. Bring DME into scan (Sim config artificiality).
	A	Ok - No changes.	Ok	Ok	-
#22	S	Ok - should give some indication that A/C is in alt hold to upper.	Green bar could be presented in the HSI - would not require constant scan of ADI during transition to upper seg.	(See ADI)	Get more of the presentation into one instrument. (See ADI/HSI)
	A	Ok - need positive indication of alt hold.	Green bar should be presented in the HSI.	(See ADI)	(See ADI/HSI)
#25	S	1. Meaningful, but probably because if announces what mode is being used and as a backup to the instruments being operable. 2. Brightness should be controllable in conjunction with instrument lights but on separate rheostat.	Contrast between pitch bar and pitch attitude indicator.	Acceptable but concerned about fly down indication at transition to lower point. Has no alternative suggestion.	(See ADI)
	A	No problem once accustomed to it.	Generally ok - believed finer graduations on sphere including 5-10-15 nose up and down. Bias pitch command bar on malfunction or go-around.	Ok.	Bias pitch command bar from view for malfunction or go-around.

DC-9/RNAV GUEST PILOT COMMENT SUMMARY

PART II - INSTRUMENTATION ANALYSIS

MODE	S/C A/C	APPROACH PROGRESS DISPLAY MEANINGFUL? / INTERPRETATION? RECOMMENDED CHANGES?	ADI SATISFACTORY? IF NOT, WHY?	HSI ACCEPTABLE? IF NOT, WHY?	OVERALL INSTRUMENT DISPLAY RECOMMENDED CHANGES
#23	S	(No Sim Questionnaire)	-	-	-
	A	No - too much of a "grocery list". Experienced difficulty acquiring and maintaining orientation. Could not get the whole picture easily.	Pitch command bar appeared to "float" during alt hold operation.	Basically ok - non-RNAV equipment displays G/S pointer only on ILS. Believe Green needle should be biased out of view when in alt hold unless gradient is anticipated.	Simplify annunciations.
#24	S	Would be same as ILS interpretation after 5-10 hours of exposure.	F/D programming and sensitivity poor on RNAV.	-	-
	A	Meaningful and required logic would be improved if referenced to runway end at all times.	1. Pitch bar too sensitive - small pitch change reflected by too large a bar movement. 2. Pitch command did not provide enough guidance to re-capture upper seg after deviation. 3. G/S raw data in view when it should be out of view. Need flag over indicator.	Prefers raw data on sid-located needle not full colored bar. Likes slaved-servoed course pointer presentation.	(See ADI re G/S data display)

DC-8/RNAV GUEST PILOT COMMENT SUMMARY

PART II - INSTRUMENTATION ANALYSIS

		APPROACH PROGRESS DISPLAY	ADI	HSI	OVERALL INSTRUMENT DISPLAY
	SIM/A/C	MEANINGFUL?/INTERPRETATION? RECOMMENDED CHANGES?	SATISFACTORY? IF NOT, WHY?	ACCEPTABLE? IF NOT, WHY?	RECOMMENDED CHANGES
#26	S	Excellent. Could be improved by the addition of 2 more lights to indicate ILS arm and capture to differentiate between 2-segment RNAV/ILS and 2-segment RNAV/RNAV. These could and should be below the "lower segment" annun.	Presentation of invalid flags at 500' on RNAV/RNAV approaches is disturbing. Recommend presentation should continue to display RNAV course and vertical deviation to MDA and then held it at MDA alt until MAP and continue it to missed approach.holding pattern. A wings level climbout attitude and course should be displayed until a predetermined point, retaining F/D commands.	Most critical area is vertical deviation presentation at lower segment capture where deviation display on the HSI drops full scale to the bottom. This occurs at a low AGL and presents a "raw data" indication command which, if followed, could result in a continuation of the high descent rate on upper segment with a fly through G/S.	(See APD/ADI/HSI)
	A	Excellent and very meaningful. (See Sim above for changes.)	-	Especially appreciated location of "Dist to Wypt" readout. HSI not acceptable - see Sim comments above re vertical deviation at "lower seg" capture.	1. Considers lower segment capture display in HSI CRITICALLY DANGEROUS. 2. Strongly recommends go-around guidance. (See Sim ADI above.)

DC-9/RVAV GUEST PILOT COMMENT SUMMARY

PART II - INSTRUMENTATION ANALYSIS

RUN	SIM A/C	APPROACH PROGRESS DISPLAY ITEMS/DETAILS/INTEGRATION RECOMMENDED CHANGES?	ADI SATISFACTORY IF NOT, WHY?	HSI ACCEPTABLE? IF NOT, WHY?	OVERALL INSTRUMENT DISPLAY RECOMMENDED CHANGES
#27	S	Yes.	Satisfactory - no changes	DME out of scan (Sim config artificiality.)	-
	A	Ok.	Satisfactory.	Acceptable.	Would like to see go-around capability on ADI and AFD.
#28	S	(No Sim Questionnaire)	-	-	-
	A	Ok - go-around should be annunciated on AFD (???)	Pitch reference for go-around should be on pitch bar.	Likes a heading bug that can be set on heading to be flown.	Good - no changes.
#29	S	Ok - no changes.	Would like FD-108 system.	-	-
	A	-	Slightly more difficult to cross-check vertical deviation on HSI and F/D command. Found raw data on vertical easier than F/D pitch command.	-	-